POWER

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Picking a Man

AS SHOWING those who apply for positions by mail the searching analysis to which their applications are subjected, I quote from a letter from the superintendent of power stations of a large company, to whom, knowing that he was looking for an engineer, I referred a number of seekers for positions.

> I believe the last paragraph is a measure of the man's abilities. He seems proud of the fact that he has "swung a scoop" and for sufficient monetary consideration could put up with our living conditions. No indication that he senses the value of the position in putting him to the front in engineering. He centers everything upon the number of dollars per day.

He was much impressed with the application of a man from a distant city, because it showed his eagerness to get on in his profession. He was not worrying about how much he was going to get per day or how much it might lead to per year, but the opportunities that the position might offer for advanced knowledge of and practice in engineering. The pay would come with that naturally. The superintendent's only hesitancy about inviting him to come on was that he might fail, through some physical deficiency, to qualify. If he had been nearer, he would have been of the called if not of the chosen.

> In the case of Mr. ——— I have considered his application many times and have arrived at the conclusion that he lacks initiative and perseverance. This is made evident from the first paragraph of his letter, in which he gives up almost before he starts. In his interview with his employers he evidently failed to show them by records and data what savings, if any, he had accomplished; for I feel that even from a cold business viewpoint, if he was able to present a good case his employers would value him higher than he says they do.

The engineer who is little accustomed to expressing himself on paper, to whom the writing of a letter to a stranger is something of a task, enters the lists with considerable of a handicap. His production, by its style and appearance, and read between the lines, discloses more of his personal characteristics than he expects that it is going to.

All about are desirable positions to be filled. It is the job of the superintendents and chief engineers to find the men to fill them. They are not hunting for the men who will work for the least money, but the men who will stick and grow and demonstrate that the man who hired them was a "good picker." The more such men can make themselves worth, the better the chief will have discharged his duty.

And the wise chief will be most interested in the apparent aims and ambitions of the applicant and his probable capabilities of realizing them, in his human characteristics and possibilities, and will regard them with more favor if the ambition is to be of real service, the aim to be a great engineer, and the outcropping personality such as would be agreeable to have around.

F. R. Low

Largest Low-Head Turbines Installed in Siphon Settings

FOUR turbines of the high-speed suction type installed in siphon settings and equipped with hydraucone regainers, drive double generators.

WHEN the United States Government constructed the dam and lock in the Hudson River in 1913-15, between Troy and Green Island, N. Y., a bulkhead (see Fig. 1) was provided between the end of the dam and the Green Island shore, containing thirteen waterways, thereby making it possible to develop the power available at the dam site. The dam is

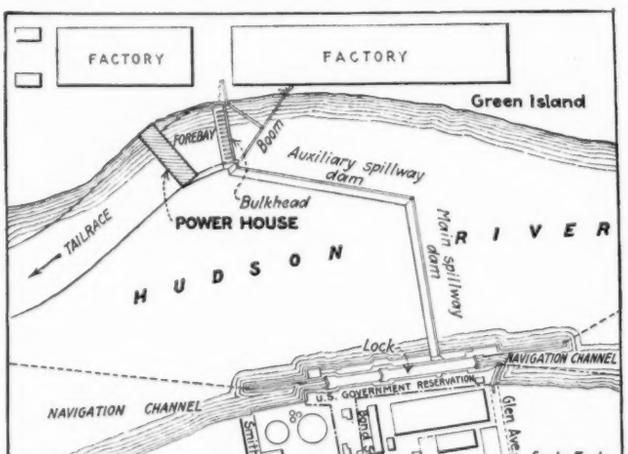

FIG. 1—LOCATION OF DAM AND POWER HOUSE

at the lower end of the New York State Barge Canal System. The idea of utilizing the water flowing over the Government dam at Green Island came to Henry Ford during one of his camping expeditions with Messrs. Edison, Burroughs and Firestone. This resulted in Mr. Ford's purchasing a large tract of land on Green Island, adjacent to the Government dam, for the construction of a manufacturing plant to utilize the power of the river.

Negotiations were begun with the Federal Water-Power Commission to secure the necessary permit to utilize the power at the dam site, and later a license was issued to Henry Ford & Son, Inc., for the development of the project. The Hudson River and its tributaries in this vicinity have a drainage of 8,100 square miles and a flow varying between a maximum of about 250,000 cu.ft.-sec. and a minimum of about 2,000. On this account the head available at the dam site varies from a few inches at the extreme high flow to about seventeen feet at the low flow. In addition to the differences of the heads mentioned, the water below the dam is subject to a tidal influence of about four feet maximum.

An analysis of the hydrographs over a period of years shows that in the average year the flow at the dam site will produce 8,000 hp. at thirteen feet average head for eight hours a day and 60 per cent of the year.

The power house is a short distance downstream from the bulkhead (Fig. 1) and is connected to it by a forebay formed by constructing a reinforced-concrete retaining wall from the river end of the power house upstream to the junction between the bulkhead and the dam. A concrete pier was built on the existing dam near the intersection of the auxiliary spillway with the bulkhead structure. The space between the bulkhead and pier serves as an iceway in which is installed a pivoted steel skimming gate, hand-operated through worm and spur gearing to permit the passing of ice and débris.

Sockets for flashboard pins are provided in the crest of the existing Federal dam. Designs are made for flashboards two feet high for the main spillway. The pins will be of such size as to fail when the flow in the river reaches a stage of four feet over the tops of the boards. The flashboards are not to be installed at this time.

A floating timber boom, in two sections each 150 ft. long and 6 ft. wide, to divert logs, ice and other

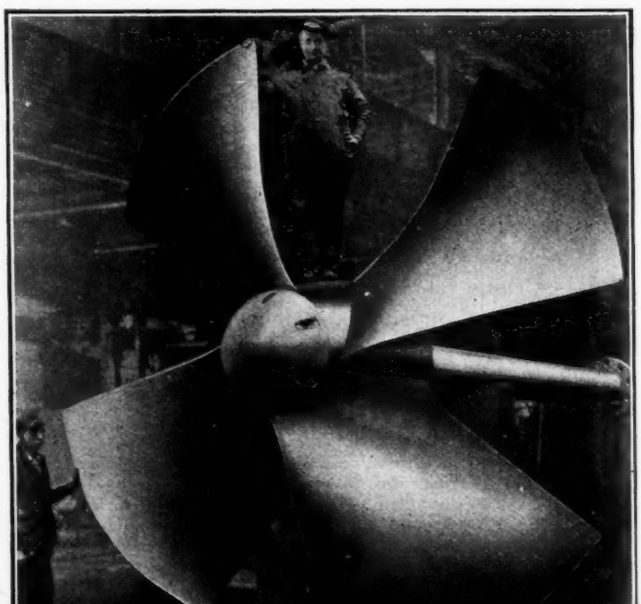

FIG. 2—CAST-STEEL 2,200-HP. RUNNER, 156-IN. IN DIAMETER, WEIGHT 17,000 LB. HEAD, 13-FT., SPEED, 80 R.P.M.

débris from the outer forebay, extends from a pier at the outshore end of the bulkhead diagonally upstream to a concrete anchorage constructed on the shore about 250 ft. from the bulkhead. At the two ends the boom bears against the concrete anchorage and bulkhead and at the intermediate point, against a pier in the channel of the outer forebay.

The outer forebay, adjacent to and upstream from the bulkhead, is dredged to a bottom elevation of 0.0 ft., or mean sea level, for a length of 700 ft. and a width of 220 ft. The inner forebay serves as a waterway from the bulkhead to the power house. It is about 150 ft. long of an average width of 195 ft., and is excavated to an elevation of about 2 ft. below mean sea level. A reinforced-concrete retaining wall is built to elevation +20 ft. along the shore side, while along the river side

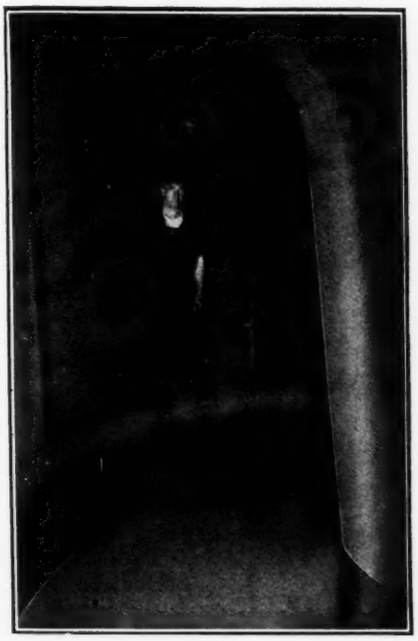

FIG. 3 — INSIDE OF GUIDE CASE SHOWING ONE BLADE OF RUNNER AT THE BOTTOM; BEARING HOUSING AT THE RIGHT AND GUIDE VANES IN BACKGROUND

FIG. 4—INTERIOR VIEW OF STATION SHOWING DOUBLE-CURRENT GENERATOR, THE KINGSBURY THRUST BEARING AND THE OIL-PRESSURE GOVERNOR

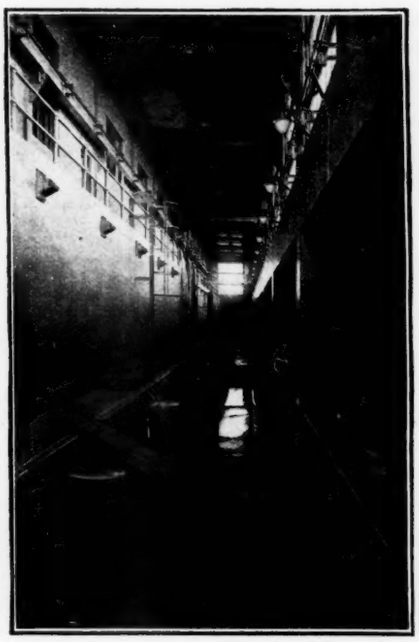

FIG. 5—VIEW IN GATEHOUSE SHOWING TRAVELING CRANE WITH GATES IN THE BACKGROUND; TRASH RACKS SPACED ON 9-IN. CENTERS

a wall of gravity type is constructed to the same height, to serve as an auxiliary spillway in times of flood.

A tailrace about 1,500 ft. long and 220 ft. wide with a bottom elevation of —6 ft. was excavated to convey the water at a low velocity from the power station to the river channel. Its bottom and sides will be unlined. At its upstream end, adjacent to the power house, the bottom will slope down to the floor of the draft tube chamber, at approximately 17 ft. below mean sea level. The downstream end will slope down to the elevation of the bottom of the navigation channel in order to obviate surface currents that would interfere with navigation. The location and dimensions of this tailrace have been determined by the requirements of the War Department.

This plant contains four units, each designed for 2,000-hp. capacity, under thirteen feet head at 80 r.p.m., the turbines being of the high-speed suction type. Each generating unit has a combined output rating of 1,800 kw. and consists of a 1,000-kw. direct-current and an 800-kw. alternating-current machine mounted on the same shaft. In physical dimensions as well as in power and discharge capacities, the turbines are the largest machines of this type in the world. They are installed in siphon settings which in themselves set a new record for size. Each turbine is equipped with a White hydraucone regainer for reclaiming the discharge losses of the runner.

Turbines of the Suction Type

The turbine runners are of the suction type developed during the period 1913 to 1919 for securing high speeds under low heads. One of them is shown in Fig. 2, its form indicating the reason for the common designation of this runner as a "propeller" type. As to its designation as being of the suction type, it may be stated simply that power is developed by reason of a suction or under-pressure action rather than by a pressure action, which means that most of the power is produced on the back side of the blades.

This suction principle involves two radical departures in turbine design. In the first place it is the back side of the runner blade that is designed to give the desired power and efficiency performance, the front side being of secondary consideration. The second feature involves a departure from some accepted rules of turbine computations, one being that the power of a runner varies as the three-halves power of the head. This law does not apply strictly because there is a definite limit to the atmospheric pressure available for producing the suction effect so vital to the horsepower of these runners of high specific speed. This feature has been pointed out by W. M. White[1] who calls attention to the fact that it is not sufficient merely to keep the sum of the static draft head and the velocity head at the discharge of the

[1]Manager and chief engineer, Hydraulic Department, Allis-Chalmers Manufacturing Co.

runner a reasonable amount below 34 ft., but that a third factor must be introduced, this third factor being a large percentage of the total head. Practically speaking, this means that high specific speeds—for example, in excess of 150—are not readily obtainable with heads in excess of 30 or 34 ft., particularly if the runner is placed at or above tail level. The specific speed of the runner varies according to the contract ratings as follows:

Head	Specific Speed
9	183
11	165
13 (*normal*)	152
15	140
17	130

Mechanically, the turbine structure is novel, in that the runner is of cast steel as contrasted to the usual cast-iron or plate-steel construction for low heads. The turbine is of the outside-gate gear type, the regulating connections being accessible in the turbine pit and not being subjected to the action of water. The application of this feature to heads as low as thirteen feet is unusual. The guide vanes themselves are built up of forged steel and plate steel to avoid excessive weight and to give a vane that will deform rather than break, in case of excessive strain on it due to foreign material. Damage to the vanes is further safeguarded by means of breaking links in the regulating mechanism.

An unusual view illustrating the relative position of the guide vanes and the runner, and incidentally showing the size of the former, is shown in Fig. 3. This photograph is made possible by reason of the turbine arrangement, which involves a considerable space between the guide vanes and the runner. During the initial tests photographs were taken in this same space with the unit in operation, the siphon setting permitting levels to be carried sufficiently low on the guide vanes to enable the engineers to open a manhole on the cover plate and observe or photograph the water as it came out of the guide vanes and to notice its action on the runner, both at normal and abnormal speeds.

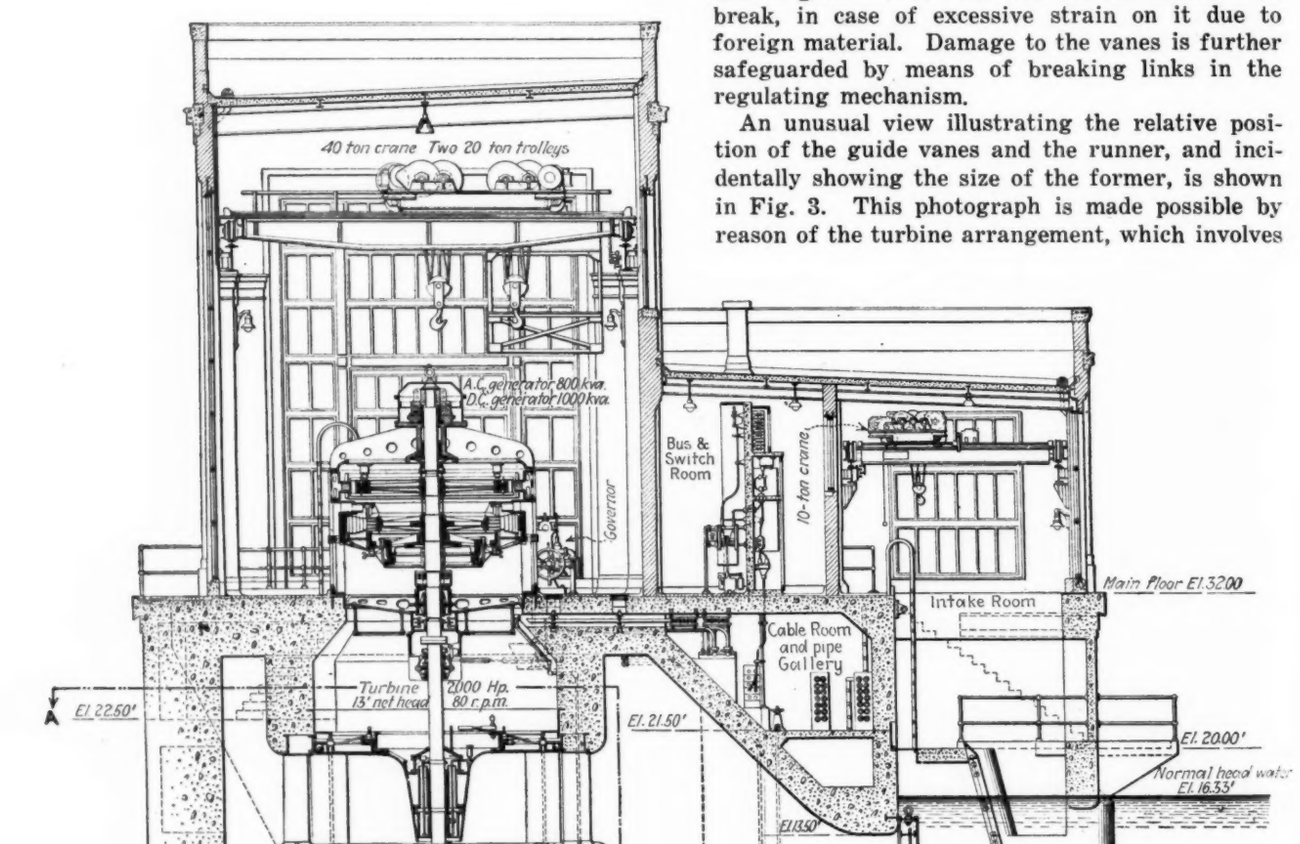

FIG. 6—CROSS-SECTION OF POWER HOUSE APPROXIMATELY THROUGH CENTER LINE OF UNIT

A distinct feature for low-head plants is found in

connection with the main steady bearing, this being of the oil-lubricated babbitted type. This is peculiarly adapted to the setting in question, as the siphon arrangement permits of greatly simplifying the bearing structure from a water-seal viewpoint.

Siphon Setting Raises the Head About Ten Feet Above Normal Level

The extent to which the siphon setting is utilized is shown in Fig. 6, which also gives a complete cross-section of the power house and indicates the relative arrangement of waterways, generating and control equipment. The headwater is lifted on an average about ten feet above its normal level. This lifting is accomplished by means of two ejectors per unit, each being operated by the normal head on the plant. One of these is arranged for manual operation for starting purposes; the other is smaller and is arranged for continuously taking out air that might collect in the top of the spiral chamber. The siphon setting is adopted so that the guide case may be placed high enough to secure the desired draft-tube proportions without involving an excessive depth of excavation.

In actual practice it is found that with the turbine gates closed, the air may be exhausted from the spiral chamber in a few hours' time. The turbine itself will clear the air up to a point considerably above the guide case within a few seconds, and pipe connections are provided to exhaust the air completely merely by the operation of the turbine itself. The ejectors are required only to cover the possibility of an abnormal condition where the head level approaches the bottom of the guide case.

Concrete Spiral Casing of Direct Type

Apart from the siphon feature the spiral casing is of the direct type as contrasted to the wrapped spiral so popular a few years ago. This is shown in the plan view, Fig. 7, the arrangement being such as to accommodate most nearly the radial direction of flow experienced in practically all turbines at the outer tips of the guide vanes. It is this greater conformity to the natural flow of the water, together with the fact that with any given spacing of units lower velocities may be obtained, that has been responsible for the better hydraulic conditions obtained with this type of spiral.

The hydraucone regainer is built of concrete, the bottom of the tailrace pit forming the impinging surface or plate. The bell of the hydraucone is of reinforced concrete. Some idea of the magnitude of its construction may be gained from the fact that the bell has a diameter of 39 ft. and a total suspended weight of over 650,000 lb. At the outlet from the draft tubes the dividing walls between units are built out to help carry the weight of the structure and to furnish suitable bearings for pontoons or cofferdams in case it is desired to unwater a draft tube. Slots are left at the bottom of the draft-tube mouths to permit the use of needle stop logs. Apart from its size the hydraucone regainer itself involves no new features beyond those described by Mr. White before the American Society of Mechanical Engineers in June, 1921.

The governor arrangement is shown in Fig. 4. The flyballs are mounted under the lower generator bearing. The control mechanisms of the governors are directly on the regulating cylinders on the main operating floor. Oil pressure is supplied by means of a central system, there being two rotary oil pumps, each of 50-gal.-per-min. capacity, driven by 12-hp. direct-current motors. The pumps, tanks and interconnecting piping are in the gallery on the upstream side of the units, an opening being provided directly over the pumping units so that they are visible from a point close to the switchboard. This arrangement works out conveniently from an operating point of view as the entire generator floor is cleared of oil-pressure auxiliaries.

An exterior view of the plant is shown in the headpiece. Special consideration has been given to securing as favorable lighting conditions as possible in all parts of the building. The trash racks and head gates are inclosed in a special gatehouse (see Figs. 5 and 6), the gates being handled by a floor-operated electric 10-ton traveling crane, which will also be used for handling large trash or ice that may lodge against the racks.

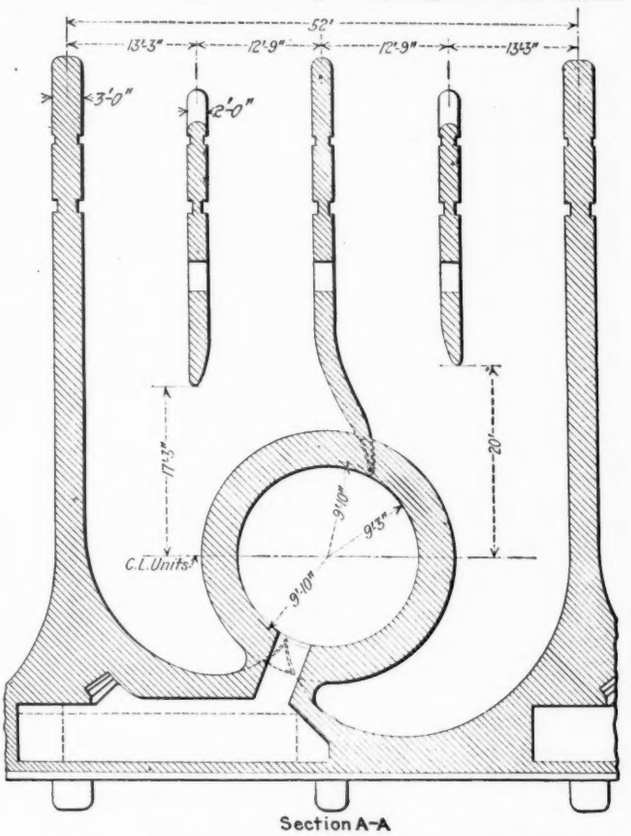

FIG. 7—PLAN VIEW OF SCROLL CASE SHOWING ARRANGEMENT OF DIVIDING PIERS, THROUGH SECTION *AA*, FIG. 6

The gates are of steel with bronze seats. One set only is provided, as access may be had to the runner and all working parts of the turbine for inspection without closing the headgates. The trash racks require practically no raking, as they have a spacing of 9 in. from center to center of bars. This spacing is permissible since the guide vanes, which are 84 in. high, have a full opening of 24 in. and the runner openings are large enough to pass anything that can go through the guide vanes. The practical result of this arrangement is that all small trash, such as clogs the ordinary racks, passes through without difficulty. The only raking necessary is to clean out large logs and timbers.

The four double generators, shown in Figs. 4 and 6, are a departure in the building of waterwheel units. The power requirements called for direct current for driving the motor equipment and alternating current for

heating and heat treating. Furthermore, it was desirable that all machines should be alike, which naturally did away with the use of separate alternating-current and direct-current machines. A so-called double-current generator was out of the question because the frequency and voltage conditions did not lend themselves to an economical design, and furthermore, independent voltage regulation was desirable. Therefore, two machines were built, consisting of a vertical direct-current generator and a vertical alternating-current generator mounted one on top of the other on the same vertical shaft.

General Features of Construction

The direct-current generator has a rating of 1,000 kw. at 250 volts, while the alternating-current machine has a rating of 800 kw. at 4,600 volts, the speed being 80 r.p.m. The general construction is similar to standard vertical waterwheel design, each double generator being provided with one upper and one lower guide bearing in addition to a Kingsbury thrust bearing mounted on the upper housing.

In general the construction consists of a base ring supporting the lower spider and guide bearing, on which is mounted a distance ring and the field yoke of the direct-current generator. These are ribbed castings providing ample passages for the free circulation of air. The alternating-current yoke or armature is mounted directly on top of the direct-current field yoke, while the upper bridge supporting the upper guide bearing and Kingsbury thrust bearing is on the extreme top.

The revolving element consists of a direct-current armature and an alternating-current revolving field. The former is made up of a cast-iron spider supporting a laminated core in the slots of which is the armature winding. The commutator is on the lower side of the spider, so that the brushes are readily accessible from the main floor. The revolving field or rotor of the alternator is mounted directly above the direct-current armature on the same shaft. The rotor consists of a cast-iron spider with split hub having the polepieces with their windings mounted on the rim.

Each machine has its own self-contained oiling system the oil flowing from the upper guide bearing through the lower guide bearing into the lower oil pan, from which a small geared pump forces it back into the upper bearing. The thrust bearing of the Kingsbury type runs in a separate bath of oil and is water-cooled.

Operating Performance

In June, 1922, the units were started up and each was subjected to full load by means of a water rheostat. The tidal variation at Troy is such that the tail level varies as much as 3 ft. This variation, combined with high water, permitted making capacity tests under heads reaching nearly the maximum for which the machines were designed. On these tests the machines have each carried loads between 2,500 and 3,000 hp. when operating at high heads up to 16 ft. When operating at normal head (13 ft.) the horsepower rating (2,000) has been exceeded by between 5 and 10 per cent. The units were also given runaway speed tests, a maximum of 155 r.p.m. being obtained under a 13-ft. head.

One of the major reasons for adopting this type of turbine was its flexibility under varying head conditions. These units will be required to operate under heads varying from four or five feet up to seventeen feet. Efficiency and capacities are guaranteed throughout the range from nine to seventeen feet. Capacity data were obtained on tests showing that the units operate normally for heads ranging from seven to sixteen feet. In view of the extreme departures in size, specific speed, siphon setting and head range, the performance of these machines has been gratifying to the engineers responsible for the design.

The plant was designed and constructed by Stone & Webster, Inc., Boston, Mass., and the complete generating equipment, including turbines, governors, generators, and oiling system, was built by the Allis-Chalmers Manufacturing Co., of Milwaukee. The switchboard and control equipment were designed and built by the owners of the plant.

A New Alloy for Firebars

The following information concerning a new alloy for firebars appeared in a recent issue of *Chemistry and Industry*.

The burning of cast-iron firebars is one of the difficulties with which the engineer has to contend, as a set of bars can quite possibly be melted in a few weeks, and the troubles thus caused in connection with mechanical stoking have been one of the serious disadvantages of this method of firing during the last century. Much light on the subject, however, has recently been thrown by researches of the International Combustion Corporation, Ltd., of Derby (England), as a result of which a new alloy, known as "Usco," a special variety of cast iron, has been devised to overcome most of the difficulties.

The action of the furnace consists of two distinct operations: (1) the melting of the iron, and (2) oxidation, but about 90 per cent of the trouble is due to oxidation. Ordinary foundry iron contains, as chief impurities, phosphorus and sulphur, which, at the high temperature of the furnace, form phosphides and sulphides of iron. These melt at about 1,740 deg. F., so that as soon as a cast-iron firebar reaches this temperature it becomes porous, and the phosphides and sulphides melt and run out, leaving an expanded mass of pure cast iron. This porous mass oxidizes rapidly at about 1,830 deg. F.; that is, at a lower temperature than ordinary non-porous cast iron, the outer layers of the bar being converted, in turn, into purer cast iron, steel, pure cast iron and, finally, iron oxide. Graphitic carbon and silicon also add to the trouble, but the main cause is the phosphorus and sulphur. The new alloy is stated to have overcome all these troubles, as it consists of a special form of purified cast iron with a much higher melting point and tensile strength. Its life is claimed to be from three to ten times that of ordinary cast iron, and it pours without difficulty and does not crack. The cost is only about 50 per cent more than that of ordinary cast iron, and the qualities of the new alloy can thus easily be tested at little expense.

The effect of a low-resistance rotor in an induction motor is to cause the maximum power to be exerted at nearly synchronous speed, while the effect of a high-resistance rotor is to cause the maximum power to occur at a low speed. The maximum power in both cases will be about the same.

Filtered steam-cylinder oils atomize more quickly than those that have not been filtered. Oils of low volatility are more economical in forming a film than those of high volatility.

Largest Automatic Hydro-Electric Station

Automatic hydro-electric stations are growing rapidly not only in number but also in size. One of the latest that has been added to the list is that of the New England Power Co. This plant is at Searsburg, Vt., near the headwaters of Deerfield River and has a capacity of 5,000 kw. in a single unit, which makes it the largest full automatic hydro-electric station so far constructed. The region where the plant is located is sparsely settled and is practically inaccessible during the winter months, so that it would not only have been difficult to maintain an operating crew at the plant, but also expensive, if a manually operated station had been installed. These factors led to the installation of a full-automatic plant, although the equipment can be changed to manual control by a double-throw 5-pole switch on the control panel.

A dam was built about three miles above the plant and the water deflected into an 8-ft. wood-stave pipe line which terminates in a surge tank on the mountainside just above the power house, Fig. 1. From this point the water is carried to the turbine in a steel penstock of the same diameter as the pipe line and is discharged into the river again. Normally, the plant will operate on the water from a drainage area of about 66 square miles, but during dry seasons this will be supplemented by water from a storage reservoir at the head of the river, about nine miles above the plant. The water is used in this plant under a head of 210 ft. and is used in five other stations farther down the river.

The equipment at the automatic station consists of one 5,000-kva. 2,300-volt three-phase 60-cycle vertical

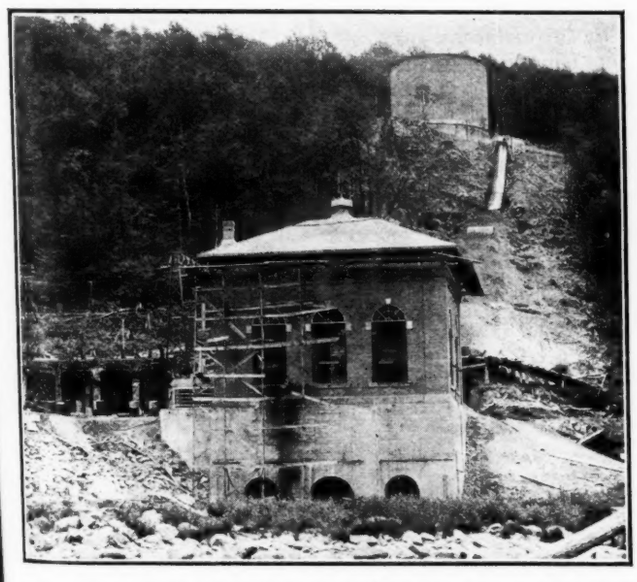

FIG. 1—STATION OPERATES UNDER A 210-FT. HEAD AND HAS ONE 5,000-KW. UNIT

waterwheel generator with directly connected exciter and automatic control equipment furnished by the General Electric Co. It is connected to an I. P. Morris waterwheel, controlled by a Woodward governor. The generator supplies power to a 66,000-volt transmission system through a 5,000-kva. bank of step-up transformers and a tie line about fifteen miles long, which connects to the high-tension busbars of station No. 5, where meters indicate, to the operator in this plant, the energy supplied by the automatic station.

When the plant was completed in March, 1922, water conditions were such that the equipment had to be started and operated on manual control until the latter part of June, during which period the unit carried 4,800 kw. practically continuously. At the end of that time the automatic equipment was tried out, and since then the station has been operating under full-automatic control carrying from one-quarter to full load.

Power to operate the control devices is supplied from a power transformer connected to the local 2,300-volt

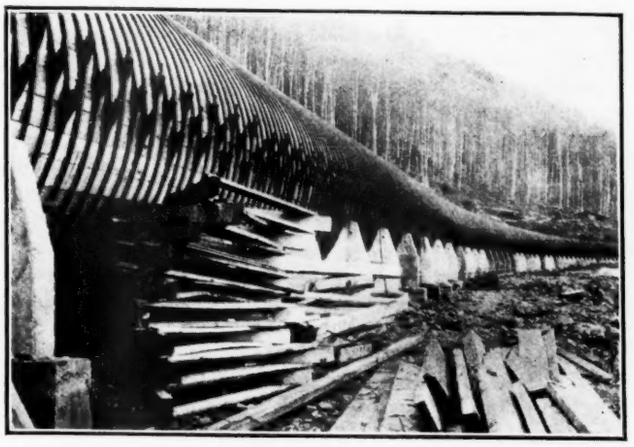

FIG. 2—WOOD-STAVE PIPE LINE EIGHT FOOT IN DIAMETER AND THREE MILES LONG

feeder, which is supplied from the station busbars and which steps the energy down to 220 volts. The station is normally started and stopped by a time switch operating at a predetermined time. The plant can be stopped by opening the oil switch at station No. 5 in the tie between the two plants. If the water in the forebay is below a certain level, a float switch opens and shuts the station down. The closing of the time switch, with the oil switch in station No. 5 closed and the water at a level in the forebay where the float switch is closed, energizes the governor solenoid, which opens a pilot valve on the turbine-gate operating mechanism and allows oil pressure to start opening the gates. At the same time the relief valves and inlet valves on the brake cylinder are operated by solenoids connected to the governor pilot-valve circuit, releasing the brake and allowing the generator to start. When the generator comes up to near synchronous speed, it is connected to the line without field and acts as an induction motor until the field switch is closed, when it pulls into step and picks up load as the waterwheel gates continue to open to some predetermined position.

The governor has been given a fairly drooping characteristic, so that the generator will not only carry approximately constant load but assist in holding the system at normal frequency. The total time taken by the automatic sequence from the closing of the time switch to when the station is on the line and carrying full load is approximately 35 seconds. Furthermore, the phasing of the generator is accomplished so smoothly that it is not noticeable at station No. 5 unless one happens to be looking at the line ammeter.

On account of the quantity of oil required for operating the brake being considerable, in comparison with the oil system available, it was decided to operate it by water from the penstock, which is properly strained. This has worked out satisfactorily and resulted in a reduction in the duty upon the governor oil system.

Steam-Turbine Governors and Valve Gears Adjusting Speed and Speed Regulation*

By EUSTIS H. THOMPSON†

SINCE the speed setting and speed regulation are so closely connected, the former adjustment can be made to better advantage if the regulating action is taken into consideration.

Speed regulation ordinarily allows a drop of 2 or 3 per cent from no load to full load, and approximately half or all in addition to the overload or wide-open valve position. In the former case a turbine at 1,800 r.p.m. no load would operate at 1,764 r.p.m. at full load, with a drop in speed of 36 r.p.m., or 2 per cent. The wide-open valve position would be expected at 1,746 r.p.m. or 3 per cent below no-load speed. The 40,000-kw. turbine described in *Power*, Aug. 28, 1922, regulates as in Table I.

If the no-load speed were raised from 1,200 to 1,250 r.p.m., we would expect the speed conditions shown in Table II to hold approximately, if all other adjustments remained the same.

Lowering the speed setting would have a similar effect in the opposite direction. The changes in regulation are due to the fact that the governor pull for one position of the flyballs varies approximately as the square of the speed. The matter of handling such adjustments will appear in succeeding pages.

THE no-load speed of a turbine depends primarily on the tension or compression of the main governor spring; increasing the spring resistance to the centrifugal pull of the moving weights or flyballs will ordinarily raise the no-load operating speed. Governor speed regulation, which is the relation between speed and the load in the unit, can be adjusted by one or more of three general methods. Changing the speed adjustment will affect regulation to some extent and vice versa; auxiliary devices present other complications. Those interested in turbines are invited to discuss practical or theoretical considerations bearing on these subjects.

There are four general ways of adjusting the speed of a valve gear: (1) Changing the tension of the governor spring, or compression in case the spring is of this character; (2) changing the amount of weight in the governor flyballs or moving weights; (3) changing the travel adjustment of the valve gear; or (4) the adjustment of an auxiliary spring acting in connection with the main governor spring. The last two are only secondary methods for small speed variations. The main no-load speed setting depends on the first two methods.

In the majority of valve gears changing the spring tension or compression is recommended for adjusting the no-load speed of the turbine. The number of active turns of the governor spring should not be disturbed as governors are usually arranged so that changing the tension or compression of the spring does not disturb the clamping elements on which the spring is screwed.

Tightening the governor spring causes the governor to speed up and also has the effect of decreasing the governor regulation. The nuts *N* in Figs. 2 and 3 are for the purpose of adjusting the speed. This is usually a desirable adjustment, as close governor regulation is ordinarily more difficult to obtain and at the same time generally gives better plant operation than broad.

Reducing the governor weights or flyballs will increase the governor speed, but this usually has the effect of broadening the governor regulation, which is ordinarily undesirable.

Changing the travel adjustment is possible where there is sufficient excess governor travel, Fig. 1, which may be used as desired. This method is not used commercially for setting the no-load speed of the governor, but on some valve gears a large excess governor travel is provided which may be adjusted at the will of the operator. The main speed setting of the turbine itself, with this valve gear, is obtained by changing the tension of the governor spring.

Fig. 1 indicates the valve gear of the small turbines manufactured by the Allis-Chalmers Manufacturing Co. This is a good example of the auxiliary speed adjustment that may be accomplished by changing the relative connection between the valve and the governor. It will be seen that the total angular travel of the governor lever is between 1,260 r.p.m. for the high-speed no-load position, in which the steam valve is almost closed, and 1,140 r.p.m. for the extreme low-speed position, in which the valve should be wide open. These speeds are only approximate for the purpose of illustration.

While the total regulation as indicated by the governor lever is 120 r.p.m., or 10 per cent, it will be seen that only a small amount of this travel is necessary to open and close the valve itself. In other words, in the present position of the valve it will be almost closed for the no-load position of 1,224 r.p.m. and wide open at 1,188 r.p.m., which gives 36 revolutions of regulation, or 3 per cent.

Now, in order to lower the speed we can change the adjusting nuts so that the valve stem is lengthened

TABLE I—GOVERNOR ADJUSTMENTS OF A 1,200-R.P.M. TURBINE

Load	Condition	Speed, R.P.M.	R.P.M. Below No-Load Speed	Per Cent Below No-Load Speed
0	No load	1,200	0	0
28,000 kw.	Most economical load—primary valve wide open	1,176	24	2
35,000 kw.	Primary and secondary valves wide open	1,164	36	3
40,000 kw.	Entire capacity	1,152	48	4

Note:—The synchronizing spring may vary the speed 5 per cent above or below any of these points.

TABLE II—APPROXIMATE REGULATION AFTER CHANGING SPEED ADJUSTMENT

Load	Speed, R.P.M.	R.P.M. Below No Load Speed	Per Cent Below No Load Speed
0	1,250	0	0
28,000 kw.	1,227	27	1.83
35,000 kw.	1,215	34.5	2.76
40,000 kw.	1,204	46	3.67

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between the governor lever and the valve. The valve will then close earlier in the stroke of the lever and will be wide open at a later position. If the extension is made to the limit of the adjustments, the governor will open the valve wide at 1,140 r.p.m. and close the valve to a no-load position at approximately 1,176 r.p.m.

Constructions of this kind in commercial turbines are accompanied by devices that limit the changes of speed. It will be noted in Fig. 1 that nuts pinned to the stem are shown at each side of the speed-adjusting nut. These allow adjustment to the limit of the travel in either direction, and provide a small margin of safety for closing the valve in the high-speed position. It is thus perfectly safe to adjust anywhere between the limits allowed by these nuts, which are pinned to the stem. Without such limits it might be possible to shorten the stem so that the valve would not close and the turbine would run away or overspeed at no load.

It is interesting to note the construction of this governor. The weights are held in place without the use of either knife-edges or bearings. They roll on flat surfaces, transmitting the thrust and reacting against flat steel springs. When the weights tend to open, there is a rolling action against the flat guides, so that they tend to roll toward the ball-bearing end. This throws the stem outward toward the governor lever, tending, in turn, to close the valve.

The governor spring is in compression, and its amount of compression can be changed by means of a spring-tension adjusting nut. This nut also contains a small locking device for safety in maintaining this adjustment. There is no method shown for changing either the amount of weight in the governor flyballs or the number of active turns in the spring for changing the regulation. Springs of this character are subject only in a slight degree to deterioration, leading to change of governor regulation. If such a change should occur, tending to broaden or lengthen the regulation, it will be necessary then to obtain a new spring from the factory, which can be installed in a few minutes.

When there is no synchronizing spring present, the governor spring can be adjusted to the proper no-load speed without great difficulty. In some types of valve gear, principally small turbines, the change of tension or compression on the governor spring makes a change of the position of the governor spindle, so that it is necessary to check the travel adjustment after the speed is changed.

In cases where there are synchronizing springs, or auxiliary springs; or hand travel adjustments for varying the speed at the will of the operator, the various requirements of the turbine should be carefully thought out before making the speed adjustment. If the speed adjustment is made in any position of the auxiliary spring, it may be that the range variation of this auxiliary hand speed adjustment will not answer the operating requirements.

In large power houses it is usually desired to carry a certain frequency. As the load conditions of the system change, it is sometimes necessary to carry a slightly lower or higher frequency than the standard. A turbine may be adjusted so that the synchronizing spring at full limit of adjustment, will allow it to carry full load under normal conditions; however, in this case somewhat less would be carried when the frequency was a little high, on account of the spring limit having been reached at the lower frequency. Before adjusting the speed of such a machine, it would be well to determine the two difficult points of speed adjustment. The greatest pull by the synchronizing spring is when the machine carries maximum load at the highest frequency. The lowest speed required by the turbine is when it is phased in or synchronized on the line at the lowest frequency encountered.

In order to adjust the speed of a turbine with the synchronizing spring at its most advantageous point, the lowest speed that a turbine must make should be the speed chosen, provided, of course that the range of the spring includes both the highest and lowest speeds required. This gives the synchronizing spring the greatest reserve at the highest speed point that may be utilized in case wear or other factors should cause the governor to drop in speed. The advantage when an assisting-type spring is used, is that there is actually less pressure against the governor under operating conditions with the spring in lower speed adjustment. The opposite is true of an opposing-type spring. Assisting and opposing types are explained in connection with Fig. 5.

To illustrate, we will take the case in which the reserve is in the low-speed side in an assisting spring, as in Fig. 5. Here it will be necessary to use practically all the tension available to obtain the high speed required in operating. Under such conditions the entire tension of the spring may cause undue wear on the governor transmission bearings as well as at other points, which would be avoided if the spring was

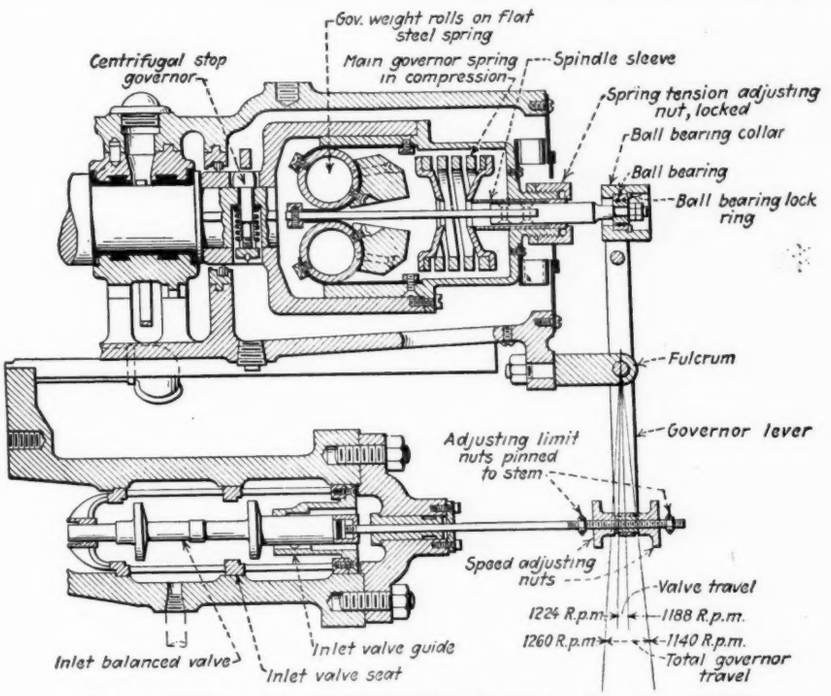


FIG. 1—SPEED VARIATION OBTAINED BY HAND ADJUSTMENT OF VALVE TRAVEL

adjusted with its reserve or surplus tension in its highest speed position, in which case all its tension would not be necesary, in usual operation.

After a turbine has been started up and placed in satisfactory operating condition, the existing governor adjustment may be satisfactory for one year or five years, or even longer, depending on the requirements and conditions of operation.

A turbine driving a direct-current generator, especially where the governor is geared to a low speed, is not easily influenced by slight governor misadjustments. If the speed adjustment becomes changed owing to wear of the governor parts or a decrease of mainspring tension so that the set operates at a somewhat lower speed, ordinarily the generator could operate at a lower voltage, if the same field rheostat setting was used. If the governor regulation should become broader, it would produce a greater drop in speed between no load and full load, which would result in lowering the voltage range of the generator under these load conditions, or in other words, "lowering the compound."

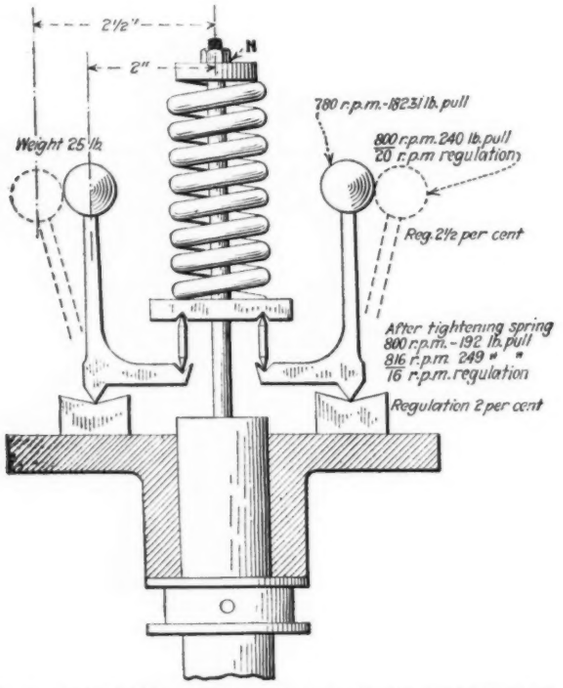


FIG. 2—GOVERNOR SPEED REGULATION SHORTENED BY INCREASING NO-LOAD SPEED

In ordinary practice the field rheostat would be cut out a trifle more at no load so as to bring the voltage up to the required amount, and if the compound is seriously lowered, the series field adjustment can be changed to bring this to normal. For slight misadjustments, therefore, the direct-current generator-turbine sets are not seriously inconvenienced.

In the case of large turbines connected to alternating-current generators in plants where the variations of load are comparatively slow, it is customary to keep the frequency of the system at the desired value by raising or lowering the speed of the turbines by means of motor-driven synchronizing springs. Under such conditions the speed is continually under hand control, and small defects of governor adjustment can be compensated for by the operator in the control room.

Alternating-current turbo-generators operating with rapid fluctuations of load, yet requiring a comparatively close or uniform frequency, such as plants for mills or factories, depend to a larger extent than large stations on correct and accurate governor adjustment in order to maintain a satisfactory value of frequency and a uniform division of the load among the units. With rapid fluctuations the synchronizing spring cannot be used satisfactorily to compensate for governor misadjustment, on account of the comparatively large time element required for operating the spring, as well as the enormous amount of personal attention involved.

Faulty Governor Regulation

Improper governor regulation allows too much or too little change of speed from no load to full load, and in common practice the former condition usually exists. A machine with too broad a regulation will undergo a smaller change of load than other machines of standard regulation with which it is paralleled. With proper governor adjustments alternating-current generators in multiple should divide the changes of load on the station in accordance with their capacities. If the station is carrying a light load correctly divided among the machines, a sudden increase in load will cause the turbo set with the broadest regulation to absorb less than its proper share of this increase. On the other hand, if a heavy station load is properly divided and a decrease in load occurs, the machine with the broad regulation will not lose its proper share of load and will tend to carry somewhat more than its share. If the entire load was gradually thrown off, this machine would soon reach a point where it would carry all the station load, and finally the other units would be motorized by current supplied from the machine with broad regulation.

In the case of direct-current machines governor inequalities may be compensated for, as before mentioned, in the case of small misadjustments, and if no compensation is made the equalizer will tend to prevent improper load distribution. Proper division of the load, however, would be interfered with to some extent, depending on the amount of governor misadjustment.

Misadjustment of governor regulation may be caused by: (1) Change of the speed adjustment; (2) deterioration of the governor spring; (3) change in the relation of governor travel to valve travel due to mechanical causes, such as excessive wear of the pilot valve, if there is one, or change of the leverage in the train of valve gear; (4) wear of governor parts resulting in change of speed; (5) change, or deterioration of the synchronizing spring. Leakage of the steam-valve element will cause speed trouble at light loads. This, however, is not classed as faulty governor regulation. In making the adjustment of governor regulation, one or more of the following methods may be utilized:

1. Increasing the speed shortens the regulation, while lowering has the opposite effect.

2. Increasing the governor weight shortens the regulation, provided the speed is readjusted to the normal value, whereas decreasing the governor weight has the opposite effect.

3. Increasing the number of active turns of the governor spring or decreasing these turns, shortens or lengthens the regulation, provided the speed adjustment is corrected after making this change.

4. Increasing the number of active turns in a synchronizing spring will shorten regulation, whether this assists or opposes the governor spring. If a movement of the governor flyballs away from the axis pulls against both the governor and synchronizing spring, they assist

each other. Where an outward flyball movement pulls against the governor spring, but is helped by the synchronizing spring pull, they oppose each other.

5. Change of the ratio of the amount of governor travel to that of valve travel. If the ratio between governor and valve travel can be changed so that the valve moves through somewhat greater distance for a given governor movement, then the regulation will be shortened. This is liable to cause hunting and is used only under special circumstances. The opposite adjustment will produce opposite results.

Adjusting the Governor Spring

Fig. 2 indicates the parts of a governor which is operating below normal speed and with too broad a regulation, say 2½ per cent. This may have happened by wearing of the governor links, thrust bearings or other parts so as to lower the speed. The turbine speed is now adjusted by increasing the spring tension by tightening the nut at *N* until the turbine reaches its normal no-load speed condition. It will then be found that the governor regulation between no load and full load is sixteen revolutions, or 2 per cent of the normal full-load governor speed, which we assume is 800 r.p.m. It will be seen that no other adjustment has been necessary. No synchronizing spring is shown, as this condition will be considered later. The approximate formula for centrifugal force, $F = 0.00003WRN^2$ is explained in Fig. 3.

Fig. 3 indicates a governor that is operating at normal no-load speed but has too broad a regulation. Suppose that the number of turns of the spring is about correct and that there are no weight plugs, although provision is made for so adding to the governor weights. A certain amount of weight is added, which we will assume to be 2.4 lb. After adding this weight we see that the governor has a much lower no-load and full-load

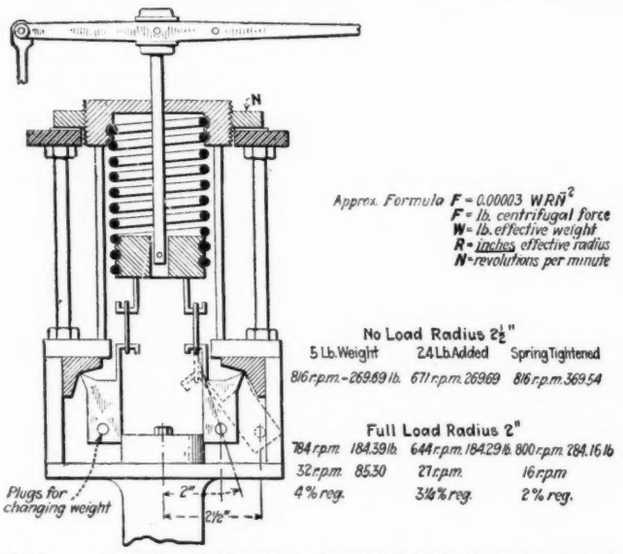
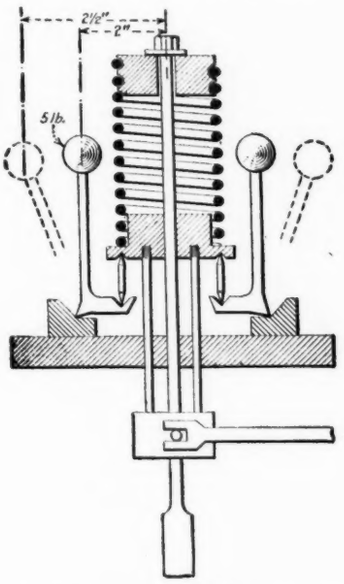


FIG. 3—ADDING WEIGHT AND TIGHTENING GOVERNOR SPRING DECREASES REGULATION

speed, and still too broad a regulation. The speed is now adjusted by increasing the governor spring tension so that the machine will operate at its normal no-load speed. We now find the regulation is exactly right. Some governors have no provision for adding weight, so that the change of the governor spring must be made as later described, instead of changing weight.

Fig. 4 shows a governor with too broad a regulation in which it is considered necessary to change the governor spring, for the reason that no more weight can conveniently be added, or else that no provision for change of weight has been made by the builder. The



	Initial Condition		Active Spring Lengthened		Speed Adjusted	
Full load	790 r.p.m. -	187.23 lb.	754 r.p.m.	170.46 lb.	800 r.p.m.	192 lb.
No "	- 816 r.p.m.	249.69	780 r.p.m.	228.15 lb.	816	249.69 lb.
Regulation	- 26 r.p.m.	62.46	26	57.69 lb.	16	57.69 lb
Regulation	- 3¼ per cent reg.		3¼ per cent reg.		2 per cent reg.	

FIG. 4—REGULATION SHORTENED BY LENGTHENING ACTING GOVERNOR SPRING AND ADJUSTING TO NO-LOAD SPEED

number of active turns of the governor spring is increased. The governor will now operate at much lower speeds just as in the case where weight was added. After adjusting to the correct no-load speed we find that the governor regulation is the desired amount.

In practical work it is preferred to decrease the governor regulation by changing the spring to the other method of changing weight, if an excessive addition of weight is involved. By studying in Figs. 2 and 3 we find that the governor spring uses a lower actual tension and, therefore, may be expected to wear longer and give better service. On the other hand, insufficient governor weight may cause hunting or surging of the governor, but this condition is seldom reached in practice unless the factory instructions as to changing the weight have been disregarded. It is often more convenient for small adjustments to regulate the governor by changing the weight rather than the spring.

Fig. 5 indicates a governor with a synchronizing spring which assists the governor spring a small amount when it is adjusted at its low-speed position, and assists the governor a very much greater amount at its maximum speed position. This spring is supposed to vary the speed of the turbine 2 per cent above or 2 per cent below the speed at which the machine would run with the spring in neutral. The governor regulation will be somewhat closer with the latter adjustment and somewhat broader with the former adjustment. In checking the regulation the no-load speed adjustment of the unit would first be corrected, in accordance with the operating conditions as before described. Regulation should then be checked with the synchronizing spring in the position that it would take in ordinary operation.

while maintaining the standard frequency of the station. Any other setting of the synchronizing spring could be used if more convenient; the final check, however, should be made in the operating position. If the number of active turns is increased in the synchronizing spring, the regulation will be shortened.

Table III shows, in the second column, the governor and synchronizing spring adjusted to give guaranteed

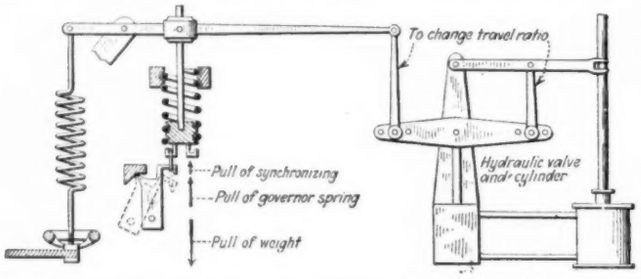


FIG. 5—STIFFENING ON ASSISTING SYNCHRONIZING SPRING INCREASES REGULATION

If the synchronizing spring shown were in compression, or if shifted to the right of the governor, it would oppose the main-spring. Stiffening an opposing-type synchronizing spring will also increase regulation. Regulation adjustments should be made on the main spring. Misadjustments due to change of auxiliary spring should be avoided.

conditions of 2 per cent regulation from no-load speed of 816 r.p.m. to normal full load of 800 r.p.m. Columns 1 and 3 show speeds at the limit of synchronizing spring adjustment. Note that regulation varies 1 per cent between these two positions. This is not an actual case, but is not far removed from what might be encountered in practice.

The effect of stiffening the spring by decreasing the active number of turns is shown at the right. The regulation under normal full-load adjustment, column 5, is broadened ½ per cent. No load speeds at the limits of adjustments are raised.

Reducing the stiffness by increasing the acting turns in a synchronizing spring has the opposite result and shortens regulation. This table is made out for an assisting type of synchronizing spring.

If the synchronizing spring were in compression,

TABLE III—SYNCHRONIZING SPRING ASSISTS GOVERNOR SPRING

Governor speed regulation is increased or broadened by stiffening the synchronizing spring, as would result from decreasing the number of active turns.

	Normal conditions: Gov. Spring Regulation, 54 lb.; Syn. Spring Regulation, 3.69 lb., effective at weight.			Conditions with Stiffer Syn. Spring: Regulation, 6 lb., Effective at weight.		
Column No.	1	2	3	4	5	6
Full-load speed	784	800	816	784	800	816
Lb. pull of gov. weight	184.4	192	199.62	184.4	192	199.62
Lb. pull of gov. spring	181	181	181	181	181	181
Lb. pull of synchr. spring	3.4	11	18.62	3.4	11	18.62
No-load speed	803½	816	828	807	820	832
Lb. pull of gov. weight	242.09	249.69	257.31	244.4	252	251.62
Lb. pull of gov. spring	235	235	235	235	235	235
Lb. pull of synchr. spring	7.09	14.69	22.31	9.4	17	24.62
Regulation r.p.m.	19½	16	12	23	20	16
Regulation per cent	2½	2	1½	3	2½	2

Radius—2 in. full load, 2½ in. no load.

however, its force would then oppose the main-spring. When the governor moved from low- to high-speed position, the force of synchronizing regulation in Table III would be subtracted instead of added to that of the main-spring. If the synchronizing spring in Fig. 5 were moved to the right of the lever arm pivot while in tension, it would oppose the main-spring. It is to be noted that if a compression main governor spring were used and arranged to produce a downward spindle movement for increase of speed, as at present, the relations would remain unchanged. The synchronizing spring as shown in Fig. 5 would still assist, and a change to a compression-type synchronizing spring would cause opposition. An assisting auxiliary spring adds its pull to that of the main-spring, pulls or pushes harder on the governor lever at no-load speed and less at full load. An opposing spring decreases the effective

TABLE IV—COMPARING ASSISTING AND OPPOSING TYPES OF SYNCHRONIZING SPRINGS AS AFFECTING GOVERNOR REGULATION

When either type is stiffened by decreasing the active number of turns, regulation is broadened. In the table the speed is adjusted to the same conditions at full load in each case. The pull of an assisting spring is added to the governor spring, while that of an opposing type is subtracted. The former exerts greater force on the governor lever at no load, while the opposed type exerts more force at the full load, position of the lever.

	Type Synchronizing Spring—Assisting		Opposing	
	Original Conditions	Synchr. Spring Stiffened	Original Conditions	Synchr. Spring Stiffened
Full-load speed	784	784	784	784
Lb. pull of gov. weight	184.4	184.4	184.4	184.4
Lb. pull of gov. spring	181	181	191.49	193.8
Lb. pull of synchr. spring	3.4	3.4	7.09	9.4
Lb. pull of both springs	184.4	184.4	184.4	184.4
No-load speed	803.5	807	803.5	807
Lb. pull of gov. weight	242.09	244.4	242.90	244.4
Lb. pull of gov. spring	235	235	245.49	245.49
Lb. pull of synchr. spring	7.09	9.4	3.4	3.4
Lb. pull of both springs	242.09	244.4	242.09	244.4
Regulation, pounds pull	57.69	60	57.69	60
Regulation, r.p.m.	19.5	23	19.5	23
Regulation, per cent	2.5	3	2.5	3

force of the main-spring against the weights. This exerts greater force on the lever, however, at full-load speed and less at no load.

Table IV compares the stiffening effect on an assisting with that of an opposing-type synchronizing spring. In each case the regulation is increased an equal amount. The opposite effect would result if the springs were made more flexible by increasing their active length.

The effect of removing a regulating spring is shown in Table V. For an assisting spring the speed would be lowered. On adjusting to normal, the regulation is decreased. With an opposing spring it can be shown

TABLE V—SPEED IS LOWERED BY REMOVING ASSISTING-TYPE SYNCHRONIZING SPRING

When adjusted to proper no-load speed, the regulation is shortened. If an opposing type were used, speed would be raised, on removal, but regulation would be decreased when speed was adjusted to normal.

	Synchronizing Spring Removed	Speed raised to Normal Full Load by Tightening Either Main or Syn. Spring or Hanging Weight on Governor Lever
Full-load speed	777	800
Lb. pull of gov. weight	181	192
Lb. pull of gov. spring	181	192
No-load speed	792	810
Lb. pull of gov. weight	235	246
Lb. pull of gov. spring	235	246
Regulation r.p.m.	15	10
Regulation per cent	2	1¼

that the speed will be raised when this is removed, which naturally follows from the fact that the governor spring would then exert greater pull against the weights. Regulation would be shortened on adjusting to normal speed.

The governor in Fig. 5 has an arrangement for changing the ratio of the governor travel to the valve travel. There is an adjustable floating lever on the pilot valve by which the valve element can be made to travel more or less for a given movement of the governor stem. Shifting one or both vertical links toward the governor would have the effect of shortening governor regulation. This ratio adjustment is usually set in a neutral position, shown in the figure. Exceptional conditions sometimes occur where this adjustment can be utilized to advantage. When the leverage is changed, the travel adjustment is also changed, and it may happen that the valve element will not close sufficiently in the no-load position, or it may not open the required amount in the low-speed position of the governor. When any change

is made at this point, the travel adjustment as well as that of regulation should be checked carefully. It should be remembered that an excessively short regulation may possibly be produced which would cause reciprocating or hunting of the valve gear. Many valve gears do not have such provisions for changing relative travel.

How to Check Governor Regulation

Before checking regulation, the travel adjustment as well as the adjustment for no-load speed should be checked. Speed of the turbine at no-load will not be correct if the valve element leaks enough to cause the machine to overspeed a small amount. The speed should be watched carefully to see if it increases an appreciable amount after the valve element reaches its no-load position. If the valves leak undesirably, it will be necessary to catch the speed with a direct reading tachometer when the valve element reaches this no-load position. In some machines the speed at the turbine shaft can be most easily read, and in other types a tachometer can sometimes be most conveniently applied to the governor spindle. When the valve element holds tightly, it is much easier simply to run the machine at no load while this speed is being determined. A hand speed counter is often used and is thoroughly satisfactory in commercial work. Speed with a hand counter should be taken two or three times in order to check the personal error of the operator. If this is taken over intervals of one or two minutes, the error is not usually serious.

Knife edges, thrust bearings or link joints may wear so as to reduce the main-spring tension or compression and also, possibly, the valve travel adjustment, so as to lower the no-load speed. This will produce broader regulation.

Governor springs after long service tend to change their elastic properties. The general effect is to lose tension or compression to some extent and also to become stiffer. This latter effect is increasingly noticeable as springs are worked closer to their elastic limits. Old governor springs, therefore, usually require the addition of weight or increase of the number of active turns, to produce normal regulation.

Loading up the flyballs with excessive weight should be avoided. Lengthen the spring and reduce weight in preference. The change in elasticity is now a well-known "fatigue" condition, which until recent years was familiar to many practical men but was not mentioned in scientific circles. Synchronizing springs are subject to the same conditions.

Summary

The no-load speed of a governor is raised by increasing the tension or compression of the main governor spring. This will shorten the governor regulation. Adjustment in the opposite direction will reverse the results. Sometimes such an adjustment changes the valve travel setting.

Lengthening the active governor spring or adding weight to the flyballs will shorten regulation. Either of these lowers the speed, so that the governor should be reset at correct no-load speed in order to measure the regulation. Reverse adjustment gives the opposite effect.

Other ways of changing regulation are to vary the number of active turns or, in other words, the stiffness of the synchronizing spring, or the ratio of valve movement to that of the governor.

The McLeod & Henry Flat Suspended Furnace Arch

A new type of flat suspended sectional furnace arch, in which any single block can be removed either from underneath or above, without disturbing any other block or the suspension, has recently been put out by McLeod & Henry Co., of Troy, N. Y.

Reference to the illustrations shows that the blocks in the flat part of the arch are of one standard size,

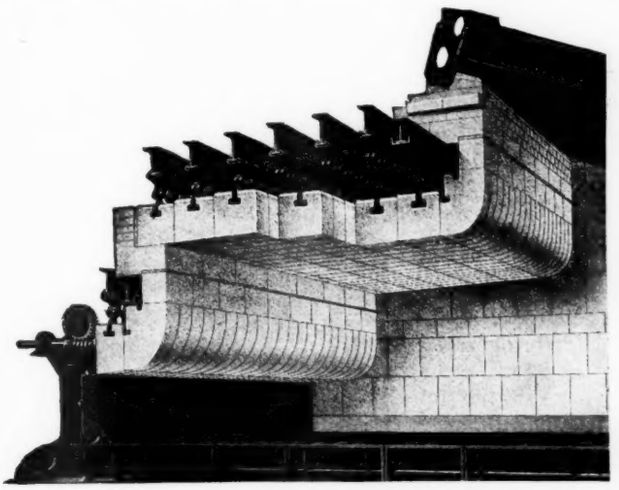


FIG. 1—PERSPECTIVE OF ARCH

interchangeable and suspended in parallel rows from the lower flanges of I-beams, each block having its own hook and rocking link.

The whole suspension is flexible, each block hanging straight downward without imposing side thrust upon its neighbors, and each block being free to move laterally in any direction. With all blocks assembled, the mass as a whole can move sidewise in any direction to compensate for internal expansion, which is made independent of that of the boiler walls by gas-tight asbestos-wool cushions at junctures of the arch proper with the other boiler parts.

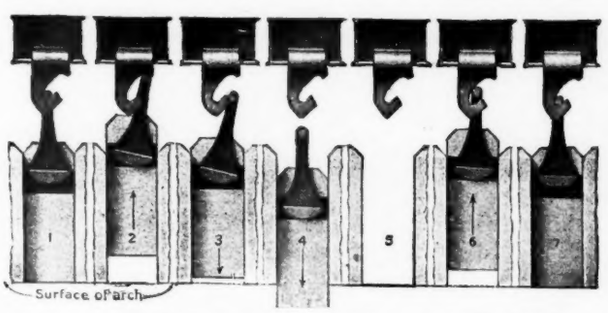


FIG. 2—METHOD OF REMOVING AND REPLACING BLOCKS INDIVIDUALLY

In the case of arches set on a slope, flat bottom surface with straight downward suspension is maintained by beveling the bottoms of the blocks to correspond with the slope and by proper adjustment of the up-and-down position of the block. The latter is accomplished by the use of different thicknesses of bearing plates to give different heights to the supporting beams.

A good polish for aluminum is a paste made of emery and tallow.

The Benson Super-Pressure Plant

By P. W. SWAIN*

THE necessity for conserving our natural fuel resources is becoming more and more imperative, and this matter is now receiving more attention than at any previous time in the history of engineering. The advance in the over-all efficiency of Diesel engines and hydro-electric plants also calls for a similar advance in steam-power production units, if these are to retain their leading position in the world of electrical generation. One of the most promising methods of increasing the thermal efficiency of steam-power plants is to raise the pressure and temperature of the steam and so design the prime movers as to utilize efficiently the increased energy drop thus made available.

Experimental plants have, in recent years, been erected and satisfactorily operated with steam pressures ranging up to 1,500 lb. per sq. in.[1] The chief difficulty at these pressures has been in the generation rather than in its use in steam turbines. Special precautions must be taken in the design, to guard against priming or the passing over of water in gulps, on account of the violent boiling of water at this pressure. It is principally due to the seriousness of this factor that pressures above 800 lb. per sq.in. have been attempted in only a few cases. The likelihood of priming increases as the pressure is raised, so long as steam is generated by methods that require the addition of latent heat with the consequent ebullition (boiling).

A LITTLE more than a century ago James Watt called Richard Trevithick a "murderer" for proposing to operate boilers at the "dangerous" pressure of sixty pounds per square inch. Today there is nearing completion, at Rugby, England, a plant designed for a minimum boiler pressure of 3,200 lb. The most interesting feature of this plant from the scientific point of view is the generation of steam without ebullition, or (in every-day speech) without boiling, by operating the steam generator in what may be called the "super-pressure" region; that is, the region above the "critical point." From the economic point of view the outstanding claims made for this plant are: (1) A large saving in fuel cost; (2) reduction in initial cost; (3) substantial saving in floor space; (4) substantial saving in weight. Avoiding abstruse technicalities, the present article explains the meaning of "critical point," "critical temperature," etc., and pictures the mechanism of steam generation at ordinary and at "super" pressures. It then describes the 1,000-kw. Benson super-pressure plant now being erected at Rugby. A second article will go more fully into the scientific principles underlying the generation and use of super-pressure steam.

The development of steam generators above this pressure has also been retarded, though to a less extent, by metallurgical difficulties. The extensive experiments carried out during the war, however, enabled a tremendous advance to be made in the production of high-tensile steel and steel alloys.

The field, therefore, has been prepared for the introduction of a super-pressure plant using steam generated under critical conditions; that is, with a pressure of 3,200 lb. per sq.in. and a temperature of 706 deg. F. The tremendous jump from 1,500 to 3,200 lb. is due entirely to the fact that at any pressure below 3,200 lb. latent heat must necessarily be added, with the consequent troubles from boiling and priming. At the critical point, however, there is no latent heat and no boiling, and this has enabled the designers, Benson Engineering Company, Ltd., of London, to construct a generator with heating elements of very small section and without steam drums or chambers.

The experimental test plant now nearing completion and soon to be erected in the works of the English Electric Company, at Rugby, England, is equivalent to a 1,000-kw. commercial plant. Steam will be generated at a pressure above 3,200 lb. per sq.in., then throttled to 1,500 lb. and, after being superheated to 788 deg. F., will be passed through a high-pressure turbine exhausting at 200 lb. per sq.in. The exhaust of the high-pressure turbine is to be reheated to 662 deg. F. and then expanded in a standard normal-pressure turbine to 29-in. vacuum. The builders of the plant predict not only that it will consume about 28 per cent less fuel that a high-grade plant of the same capacity operating at 250-lb. pressure, but that it will also be cheaper to build and maintain. As a matter of fact the actual test generator, complete with feed pump and fan, has cost less than a normal water-tube boiler of the same kilowatt capacity even though every part has been special. Further sets should, of course, cost even less.

The plant exemplifies one of many possible arrangements using steam generated at the critical point. The fundamental ideas involved in this method of steam production are covered by patents granted to the inventor, M. Benson, of London, or applied for by him in all civilized countries.

The adjective "super-pressure" in the title is used not merely to convey the idea of an extremely high pressure, but more particularly to denote steam in the little-known region above the "critical point." Used in this sense, it definitely characterizes the Benson process of power generation. This being the case, it is essential that the reader obtain a clear understanding of such terms as "critical pressure" and "critical temperature" before attempting to study the details of the Benson plant.

What is the critical point? The question might be answered (for water), "706 deg. F. and 3,200 lb. per sq. in," but this answer does not satisfy, because it gives no physical picture. Another answer might be: "The critical point is that combination of pressure and temperature at which water and steam have the same properties; that is, the same weight per cubic foot, the same heat content, etc." The temperature and pressure at which this occurs are called the "critical tempera-

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[1] In this article all pressures are in pounds per square inch absolute and all temperatures in degrees Fahrenheit.

ture" and "critical pressure" respectively. These constants are not accurately known, modern authorities differing as to the exact values. The figures previously given are from the Marks and Davis steam tables, and will be used throughout this article with the understanding that they are merely close approximations subject to correction with future steam-table research.

Perhaps the best way to get a mental picture of the critical point is to consider the heating up and evaporation of one pound of water, first at ordinary pressures

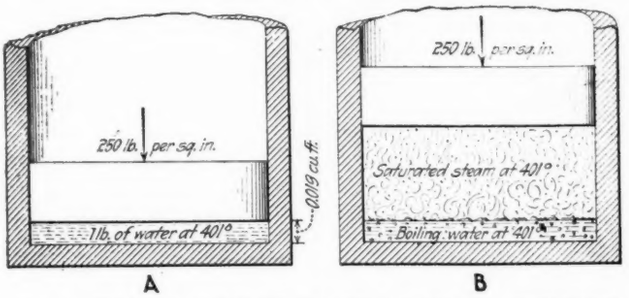


FIG. 1—EVAPORATION OF WATER AT 250 LB. PRESSURE

and then at the critical pressure. These processes are shown diagrammatically in Figs. 1, 2 and 3.

Fig. 1 pictures the heating up and evaporation of one pound of water under a constant pressure of 250 lb. per sq.in. absolute. Diagram *A* shows one pound of water in a cylinder where this pressure is maintained by a frictionless weighted piston. If the water were originally at a temperature of 60 deg. F., its volume would be 0.016 cu.ft. When heated up to 401 deg., the boiling temperature at this pressure, its volume would be 0.019 cu.ft. as shown at *A*. The difference between these two volumes would hardly be noticed on a diagram of this size.

Steam Ordinarily Generated by Boiling

When more heat is added, the water boils, generating steam which raises the piston. This steam is so much less dense than the water from which it is formed that the piston may rise to the position shown in *B* with hardly a noticeable fall in the water level. When the water is half evaporated, the piston will be as shown in *C* of Fig. 3. Complete evaporation is shown at *D*. Here the 0.019 cu.ft. of water has become 1.85 cu.ft. of steam.

Any further addition of heat must superheat the steam with further expansion, as shown at *E*. Summarizing what we have seen, we may say that when heat is applied to water subjected to ordinary boiler pressures, there is a slight expansion up to the boiling temperature, then a very great expansion (in this case 97.4 times) as the water changes to saturated steam, and finally a further considerable expansion with superheat.

At the critical pressure of 3,200 lb. the story is very different, as may be seen from Fig. 2. The first sketch (*a*) shows one pound of water at 60 deg. under a piston loaded to 3,200 lb. per sq.in. The volume is 0.016 cu.ft. As heat is applied and the temperature increases, the expansion is at first hardly noticeable, the volume at 401 deg. being only 0.019 cu.ft. as before. As the temperature continues to rise, the expansion is more and more rapid, until at 706 deg. the pound of water has a volume of about 0.05 cu.ft., or three times that at the start. This condition is shown at *b*.

In the previous example, at 250 lb. pressure, no increase of temperature occurred after the boiling point was reached until all the water was evaporated. In this case 706 deg. is the "boiling point," or the temperature at which "evaporation" takes place. Here also all the water is turned into steam at a definite temperature. In other respects, however, the action is entirely different from that at lower pressures.

Steam Generated at Critical Point Without Boiling

At the 250-lb. pressure latent heat was added to the liquid, forming small particles of steam, which, in rising through the liquid, caused boiling. Gradually then, the whole of the liquid boiled away with a great increase of total volume. The amount of heat required to raise the temperature of the fluid to boiling point was only 375 B.t.u., but a much larger amount of heat (826 B.t.u.) was required to convert the liquid into steam at the same pressure and temperature. This simply means that a larger amount of energy was required to push the molecules apart against their mutual attraction and against the pressure of the piston, than was required to bring the liquid up to the boiling point.

At the critical pressure of 3,200 lb. per sq.in. the fluid would still be a liquid at 706 deg. If, however, the slightest amount of heat is further added, the whole mass changes almost instantaneously into the same volume of vapor without the addition of any latent heat whatsoever. This is shown in the diagram at *C*. As the latent heat is non-existent at this pressure, boiling

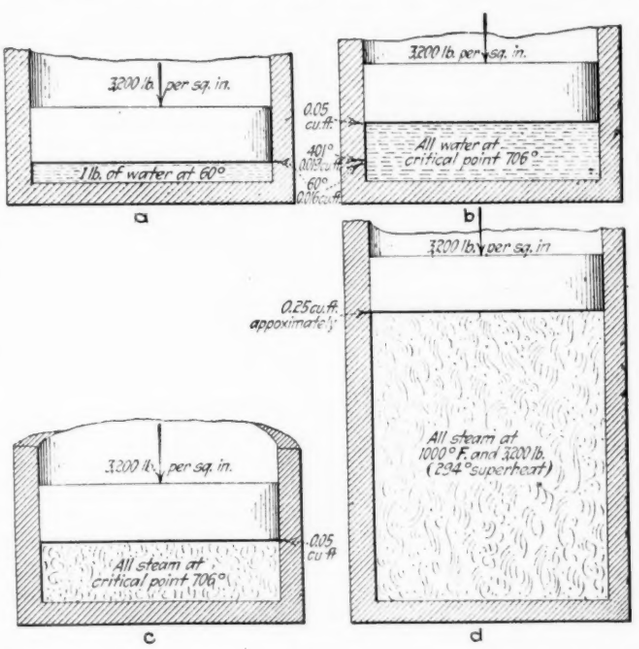


FIG. 2—HEATING UP AND EVAPORATION OF WATER AT CRITICAL PRESSURE (3,200 LB.)

does not take place, so that priming difficulties become impossible.

On second thought this does not seem unreasonable. We know that water, being practically incompressible, expands as the temperature goes up. We also know that saturated steam contracts as the temperature rises, on account of the corresponding rise in pressure. It might therefore be expected that at some high temperature the density of water should be the same as the density

of saturated steam. There is in fact such a temperature, and it is 706 deg., the critical temperature.

The pressure must be at least 3,200 lb. to keep the water from evaporating before this temperature is reached. Granted this minimum pressure, the water must turn into the same volume of steam at 706 deg. Since there is no change of temperature or volume in this transformation, it is evident that no energy is required to speed up the movement of the molecules, to separate the molecules against their mutual attractions

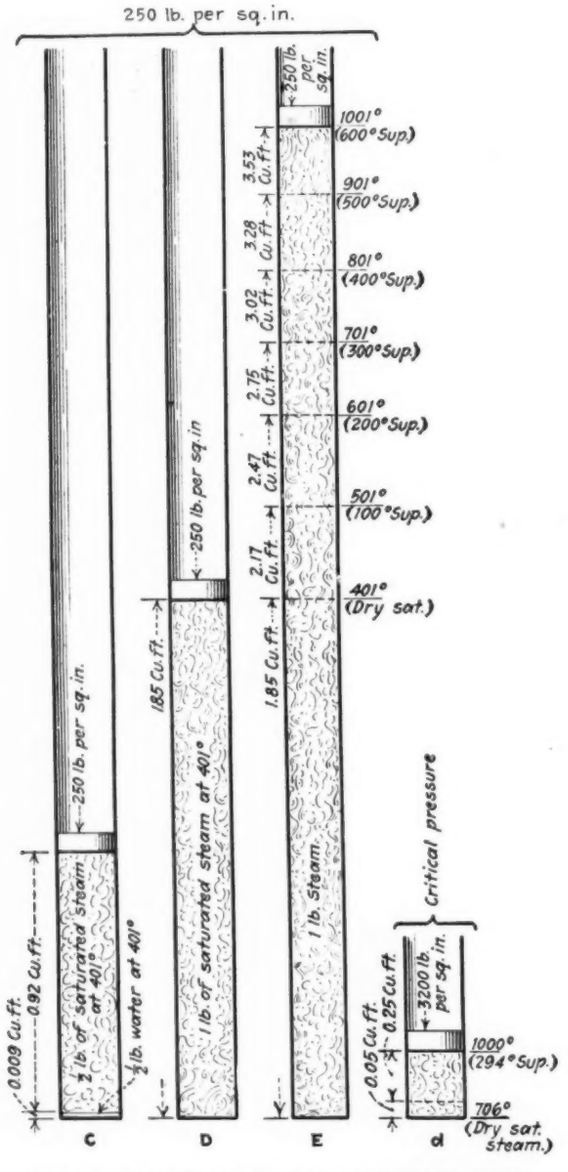


FIG. 3—EVAPORATION AND SUPERHEATING

C, D and *E*.....continuation of *A* and *B* of Fig. 1.
d.....repetition of *d* of Fig. 2.

or to do external work in raising the piston. Hence no heat at all is required to "evaporate" the water after it has once reached 706 deg. Since no heat is required for the change, any amount of heat added, however small, will instantly turn the whole mass of water into steam without boiling. Further addition of heat will superheat the steam and expand it as shown in *d* of Fig. 2. This diagram is repeated to a smaller scale in *d*, Fig. 3, for comparison with the 250-lb. steam at the same temperature.

We may now tabulate a few facts about the critical point of water as follows:

Critical temperature	706 deg.
Critical pressure	3,200 lb.
Volume of one pound water at critical point	0.05 cu.ft.
Volume of one pound of steam at critical point	0.05 cu.ft.
Change in volume during evaporation	Zero
Heat of the liquid	908 B.t.u.
Latent heat of evaporation	Zero
Total heat of saturated steam	908 B.t.u.

A comparison of the properties of water and saturated steam at various temperatures up to the critical point is given in Table I. This shows some interesting things. One is the increasing rate of expansion of water with temperature as the critical point is approached. Another is that the volume of a pound of saturated steam at 400 deg. (247 lb. per sq.in.) is 37 times that at the critical point, and the volume at 212 deg. is 536 times that at the critical point.

As might be expected, the heat of the liquid rises and the heat of vaporization falls as the temperature increases. For most of the way the rise of one practically cancels the fall of the other, so that the total heat of

TABLE I—PROPERTIES OF WATER AND SATURATED STEAM FROM 32 DEG. F. UP TO THE CRITICAL POINT*

Temp., Deg. F.	Press., Lb. per Sq.In. Abs.	Density, Lb. per Cu.Ft.		Volume, Cu.Ft. per Lb.		Heat, B.t.u.		
		Water	Steam	Water	Steam	Liquid	Vaporization	Steam
32	0.089	62.4	0.000304	0.0160	3,294	0	1,073	1,073
100	0.95	62.0	0.00285	0.0161	351	68	1,036	1,104
200	11.52	60.1	0.0298	0.0166	33.6	168	978	1,146
212	14.7 (Atmospheric)	59.9	0.0373	0.0167	26.8	180	970	1,150
300	67	57.3	0.0155	0.0174	6.46	270	909	1,179
400	247	53.5	0.534	0.0187	1.87	374	827	1,201
500	679	48.7	1.45	0.0206	0.69	484	727	1,211
600	1,540	41.8	3.53	0.024	0.28	604	585	1,189
690	2,883	32.1	9.00	0.031	0.10	.....	.....	.....
706	3,200 (critical point)	20.1	20.1	0.05	0.05	908	0	908

* These figures are from the Marks and Davis steam tables, except that the "heats" in the last line are taken from the Mollier diagram shown in the next article.

steam stays between 1,100 and 1,200 B.t.u. up to about 610 deg. There is then a fall to 908 B.t.u. at the critical point.

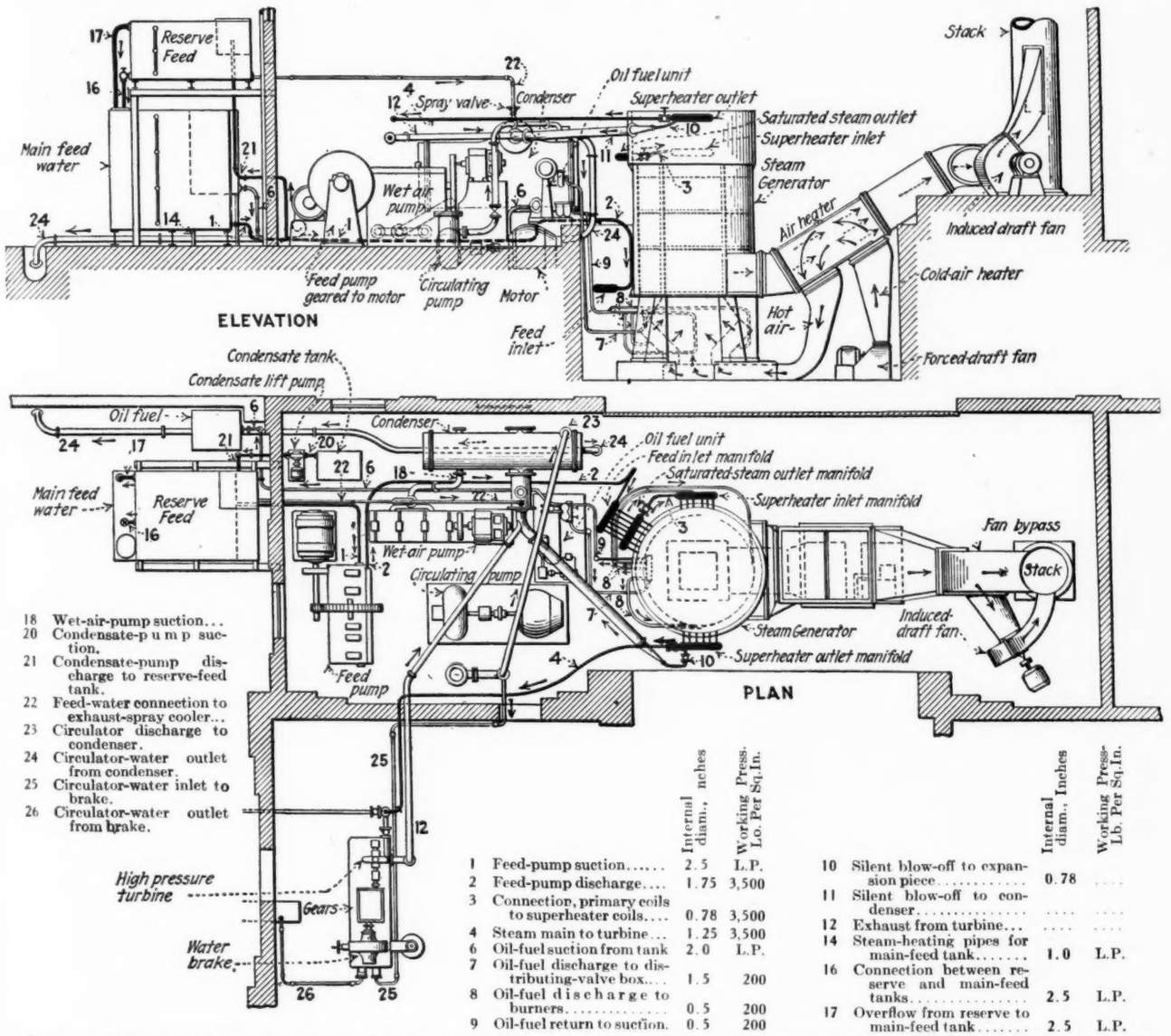
Necessity of Superheating High-Pressure Steam

A high-range Mollier diagram (such as will accompany the next article) will give the saturation line up to the critical pressure and show the rapid fall in the total heat as the pressure approaches this point. The Mollier diagram also shows that at the critical point, expansion, either adiabatic or at constant total heat, would result in an immediate return to a very wet condition. Therefore, as a working fluid for prime movers, steam at the critical pressure is not suitable unless it contains a considerable degree of superheat. Even at pressures considerably below the critical a high degree of superheat is necessary for maximum economy. This, however, does not mean a decrease in the amount of water evaporated per pound of fuel, as the total heat of steam at 3,200 lb. pressure and superheated to 910 deg. is the same as the total heat of steam at 200 lb. and 662 deg. The total heat is 1,350 B.t.u. in both cases. It is probable, however that some pressure lower than the critical would give maximum efficiency in a turbine installation, and the Benson Engineering Co. believes that a pressure in the neighborhood of 1,500 lb. and a total temperature of 850 deg. F. would, at the present time, be the most efficient and workable for a combined high-pressure and low-pressure plant of 1,000-kw. capacity.

The next article will show how to figure the saving due to higher pressures. For the present we will simply take this saving for granted, noting that, at least for low degrees of superheat, there seems to be little thermal gain in going beyond 1,500 lb. for ordinary methods of operation.

Whether the steam is to be used at 1,500 lb. or 3,200 lb., the Benson plant invariably generates it above the critical point, throttling down to the lower pressure before superheating. The throttling involves no heat loss and permits the steam to be generated *without* ing completion and soon to be erected and tested at the Rugby works of the English Electric Company, which is constructing the high-pressure turbine in collaboration with the Benson Engineering Company.

The various pieces of apparatus mentioned in the following description may be identified by notes on the drawing. Starting from the main feed tank at the left the feed water passes through pipe (1) to the motor-driven hydraulic feed pump by which it is delivered to pipe (2) at a pressure somewhat above 3,200 lb. From this it is carried to the feed manifold near the base of



18 Wet-air-pump suction...
20 Condensate-pump suction.
21 Condensate-pump discharge to reserve-feed tank.
22 Feed-water connection to exhaust-spray cooler...
23 Circulator discharge to condenser.
24 Circulator-water outlet from condenser.
25 Circulator-water inlet to brake.
26 Circulator-water outlet from brake.

		Internal diam., nches	Working Press. Lo. Per Sq.In.
1	Feed-pump suction.....	2.5	L.P.
2	Feed-pump discharge....	1.75	3,500
3	Connection, primary coils to superheater coils....	0.78	3,500
4	Steam main to turbine...	1.25	3,500
6	Oil-fuel suction from tank	2.0	L.P.
7	Oil-fuel discharge to distributing-valve box....	1.5	200
8	Oil-fuel discharge to burners.....	0.5	200
9	Oil-fuel return to suction.	0.5	200

		Internal diam., Inches	Working Press-Lb. Per Sq.In.
10	Silent blow-off to expansion piece.....	0.78	.....
11	Silent blow-off to condenser.....	.....	.....
12	Exhaust from turbine...	.....	.....
14	Steam-heating pipes for main-feed tank.....	1.0	L.P.
16	Connection between reserve and main-feed tanks.....	2.5	L.P.
17	Overflow from reserve to main-feed tank.....	2.5	L.P.

FIG. 4—EXPERIMENTAL 1,000-KW. PLANT AT RUGBY (PATH OF FEED WATER AND STEAM SHOWN IN SOLID BLACK)

boiling. This is important because priming difficulties increase at high pressures, with the result that large disengaging surfaces are required. Large disengaging surfaces mean large tubes or at least large drums. It is difficult to build these strong enough for extremely high pressures. By generating steam above the critical point, boiling is done away with and priming therefore becomes impossible. This permits the use of small tubes built in the form of continuous coils.

With this rather long but necessary introduction, the actual description of the Benson plant presents no great difficulties. Fig. 4 shows the 1,000-kw. plant now near- the steam generator and passes up through five continuous coils encircling the interior of the generator. These coils are located in an annular space between the outer and inner walls, both of which are made of refractory material. The inner wall incloses the combustion space, the oil burners and air inlet being at the bottom so that the gases rising in the central position pass downward over the coils. This arrangement makes operation proceed on the counter-current principle with the exit gases meeting the relatively cold feed water at the inlet.

As the water rises, its temperature steadily increases until, after traversing perhaps 90 per cent of the pri-

mary generating coils, it reaches the critical temperature of 706 deg. At this point it slips instantaneously and completely into saturated steam without change in density or total heat. As already explained, this transformation occurs without boiling.

During the remainder of its passage through the primary coils the steam acquires a small amount of superheat. This must be allowed in order to provide a margin of safety to insure that the critical point is passed before the fluid leaves the primary coils. The steam at 3,200 lb. and a temperature of about 730 deg. emerges from the generator to the upper steam manifold and then passes to the lower superheater manifold through a reducing valve and the connection (3). This valve throttles the steam down to 1,500 lb. and brings it back practically to the saturated condition[1].

In the test plant the slightly superheated steam at 1,500 lb. has its temperature raised to about 790 deg. in passing up through the superheater coils. These

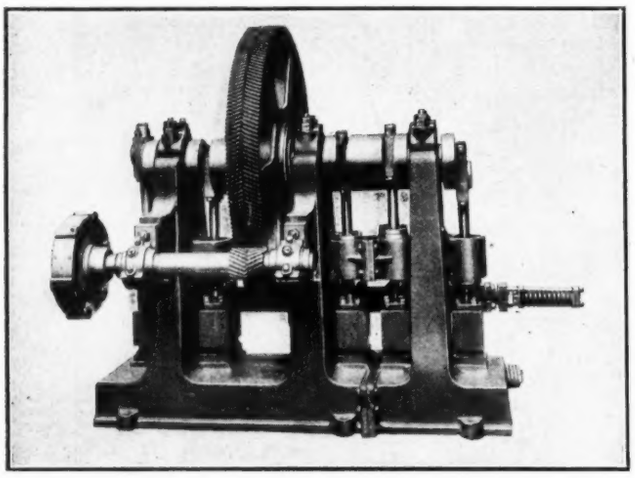


FIG. 5—HYDRAULIC FEED PUMP FOR RUGBY PLANT

are similar in construction to the primary coils, but of heavier section and are placed directly above them.

Steam formation may also take place in the following manner: The temperature of the water in the primary generating coil is brought up to only 706 deg., and the fluid, starting at this temperature, is expanded in a nozzle down to a lower pressure with the resultant partial vaporization. Complete evaporation and superheating to the desired temperature is then carried out in the superheater.

The superheated 1,500-lb. steam is conducted through pipe (4) to the high-pressure turbine shown in the lower left corner of the plan view. This turbine, noteworthy for its extremely small size, is designed to generate at least 464 brake horsepower when exhausting at 200 lb. absolute. In the experimental plant it is considered unnecessary to provide the low-pressure turbine for the preliminary experiments, so the 200 lb. exhaust is passed through a reducing valve and desuperheating spray to the condenser. The power of the high pressure turbine is measured by a water brake connected through a reducing gear.

After satisfactory operation has been attained with the present plant, it is planned to install a low-pressure turbine to operate on the reheated (to about 660 deg.) 200-lb. exhaust of the high-pressure turbine and then exhaust to the condenser at 29-in. vacuum. Since the steam consumption of the low-pressure turbine can be guaranteed from previous experience, it is obviously practicable to predict the performance of a complete plant from that of the experimental plant using the high-pressure turbine only.

The arrangement of oil-burning equipment, condensing equipment, etc., is shown on the drawing, but need not be discussed here as it operates under conditions substantially the same as those found in an ordinary plant. It should be mentioned, however, that smaller steam and fuel consumption will result in reduced size and cost of condensing and oil-burning equipment as well as stack, draft fans, etc. In the case of the feed pump, on the other hand, the high pressure far more than balances the smaller amount of water handled, with a resulting increase in its cost and power consumption.

Provision Made for the Installation of Various Automatic-Control Devices

Returning to the consideration of the generator, the outlet gases at the base pass through an air heater, where they give up much of their heat to the incoming combustion air. As the test plant will operate under a constant load, automatic control is not necessary, but provision is made for automatic devices to maintain the pressure of the steam in the generator and its temperature as it leaves the superheater. The steam pressure may be controlled by a small hydraulic accumulater floating on the feed line between the feed pump and the generator. This would operate a rheostat, which would control the feed-pump motor drive to maintain a constant feed pressure. Alternatively, provision may be made to control the speed and the consequent output of the feed pump by a pressure-regulating device operated from a pressure stage in the main turbine, thus insuring a reduced output for reduced loads. The reducing valve between the primary coils and the superheater coils automatically reduces the pressure to 1,500 lb.

The final temperature of the steam leaving the superheater valves can be regulated by a series of movable dampers located between the primary and secondary heating elements. These dampers can completely shut off the superheater if required.

Provision is also made to regulate the final temperature by a thermostat in the steam discharge to maintain the desired temperature. This thermostat would automatically control, through electric motors, the supply of air or fuel oil. As in the case of the feed pump, provision is also made to control the air supply and the fuel pumps by a pressure-regulating device operated from a pressure stage of the main turbine.

Comparison on Water-Rate Basis Is Misleading

In comparing such a plant with one working at normal pressures, it is important to get away from the idea of "water rate" or steam consumed per kilowatt-hour. While this has significance in determining the requirements, size and cost of the feed pump, condensing equipment and plant generally, it is obviously misleading to compare high- and low-pressure plants on the basis of steam consumption when the total heat of the steam differs in the two cases. Such a comparison is particularly misleading where one plant reheats the steam between the high-pressure and low-pressure turbines. The only fair basis of comparison is the over-all plant performance expressed in thermal efficiency or B.t.u. consumed per kilowatt-hour.

[1]The next article will explain why throttling at very high pressures reduces the superheat, instead of increasing it as at ordinary pressures.

In advance of an actual test there is of course an element of chance in estimating the efficiency to be obtained from this plant. This uncertainty arises from two sources, the first being a possible inaccuracy in the high-range steam-table data upon which all computations must, for the present, be based. Secondly, errors may occur in estimating the steam-generator efficiency and the percentage of theoretical energy drop that will actually be realized by the high-pressure turbine.

Assuming the correctness of the steam-table data used, the theoretical thermal efficiency of a perfect plant working on the cycle used at Rugby would be 42.5 per cent on the following assumptions: Feed temperature, 80 deg. F.; steam entering high-pressure turbine, 1,500 lb. and 788 deg.; exhaust pressure of high-pressure turbine and inlet of low-pressure turbine, 200 lb.; reheat to 662 deg. for low-pressure turbine inlet; exhaust at one-half pound.

High Over-all Efficiency Expected

An actual over-all plant thermal efficiency of 22.3 per cent is expected by the designers. This is based on the following assumptions:

Total steam generated per hour, lb.	10,000
Efficiency of steam generator without auxiliaries, per cent	80
Part of available heat drop delivered as power at turbine shaft:	
High pressure, per cent	60
Low pressure, per cent	70
Efficiency of electrical generator, per cent	95
Electrical power used by auxiliaries:	
Feed pump, hp.	56
Draft fans, hp.	30
Fuel oil, hp.	2
Condenser, hp.	20
Total, hp.	108
Net output of plant	1,482 hp. or 1,107 kw

The percentages here given are those used by the designers and can, of course, be verified only by tests on the completed plant. These figures, it must be remembered, are for a 1,000-kw. plant operating under the pressure and temperature conditions outlined. A larger plant operating under the same conditions should give a considerably higher efficiency. Table II compares the cost, weight and efficiency of a normal 1,000-kw. plant with those of a Benson plant of the same size.

TABLE II—COMPARISON OF 1,000-KW. BENSON PLANT WITH ORDINARY 1,000-KW. PLANT

Turbine admission pressures 1,500 lb. and 200 lb. respectively. Total temperature 840 deg. F. in both cases.

	Low-Pressure	Benson
A—Steam Generator		
Relative initial cost including auxiliaries	100	75
Relative weight	100	60
Relative efficiency	100	109
B—Turbine, Condenser and Electrical Equipment		
Relative initial cost	100	90
Relative weight	100	85
Relative steam consumption	100	70
C—Complete Plant		
Relative initial cost	100	82
Relative weight	100	75
Relative thermal efficiency	100	135

The matter of safety has been given much thought by the designers and is one of the prime reasons for generation of steam at the critical pressure even where it is to be applied at a lower pressure, say 1,500 lb. As has already been said, generation at the critical point eliminates priming and thus makes possible the use of small tubes with walls of reasonable thickness (the internal diameter is 0.8 in. and the external 1.2 in.). It also permits the use of continuous coils without drums or large headers. The small tube manifolds shown in Fig. 4 have an internal diameter of 3 in. and are autogenously welded to the tubes. The total hot-water and steam content of a 1,000-kw. system amounts to about 0.25 ton, while the steam main to the high-pressure turbine has an internal diameter of only 1¼ in. This is made possible by the great density of high-pressure steam.

The generator tubes are being furnished by a Continental concern, which has for 15 years been manufacturing tubes for "superheated water" chemical-process systems operating at temperatures and pressures well up toward the critical point. For the present plant the tubes are made of carbon steel, but special chrome-nickel alloys are being considered for the superheating coils of future plants designed to operate at higher temperatures.

It must not be thought that the Benson patents are limited to the particular design and operating conditions of the Rugby Plant. This is only one of many possible combinations. The basic principle is that steam is generated at the critical point. After that it may be superheated with or without throttling and at constant pressure, constant temperature, or in any other manner. Expansion may take place with or without stage reheating. Other liquids such as mercury, sulphur dioxide and solutions of solids in water, may be employed alone or in combination. In other words, the patent specifications cover, so far as possible, all possible types of plants in which the working fluids are first carried up through the critical point.

After the present plant has been brought to a basis of successful operation, there are various ways in which the efficiency of future plants may be increased. In the first case increased capacity should result in a higher ratio of actual to theoretical efficiency; secondly, higher pressures and superheats may be employed in several stages, finally, use may be made of stage bleeding.

Owing to the novel features in the high-pressure turbine, details of the design are, at present, not available for publication, but it may be said that the experimental turbine will have only one impulse wheel of a very small diameter, which will rotate at from 20,000 to 25,000 r.p.m. Expansion will take place in the nozzle of this high-pressure turbine from 1,500 lb. and 788 deg. F. down to 200 lb., corresponding to an adiabatic heat drop of 196 B.t.u. The high-pressure turbine will eventually be gear-connected to a standard low-pressure turbine which will run at 6,000 r.p.m. On account of the very high pressures and temperatures carried, special provision had to be made for the shaft and valve-spindle packings and attention has been given in the design to the restriction of windage and friction.

Comparative Cost, Weight and Size

While this plant is expected to consume about 28 per cent less heat per net kilowatt-hour than an ordinary high-grade plant of the same capacity, its steam consumption, owing to the combined effect of reheating and different total heat in the steam, should be about 30 per cent less. This would mean a reduction of approximately 20 to 30 per cent in the weight, cost and power consumption of the condensing equipment. The high-pressure feed pump, on the other hand, will cost considerably more and require several times the power to operate. The cost and power consumption of draft fans and fuel-oil equipment should be less on account of the reduced fuel consumption. It is also claimed that the boiler, even including the feed pump, will cost much less than the boiler and feed pump of an ordinary low-pressure plant.

It is expected, barring unforeseen delays, that tests on the plant at Rugby will be made this summer.

Grounded Line Not Always Negative

BY EDGAR P. SLACK

There is an opinion still more or less prevalent among electrical men that in the ordinary grounded circuit the live side is always positive and the grounded side negative; in fact, the terms "live" and "positive" are sometimes used interchangeably, as are also "grounded" and "negative." The following illustration shows that this conception is not always correct and may be misleading.

In electric railway work the trolley wire or third rail is generally positive and the grounded track negative, but in this case there is a special reason for this choice of polarity. Here one side of the circuit is in direct contact with the earth throughout its entire length, without insulation, as a result of which more or less current is allowed to flow through the earth, buried pipes, and the like, in multiple with the track itself. These earth currents would have harmful electrolytic action on the buried pipe lines if the tracks were positive; and it is principally to do away with electrolytic corrosion that the grounded track is made negative.

In ordinary direct-current light and power work current is supplied from an Edison three-wire system with

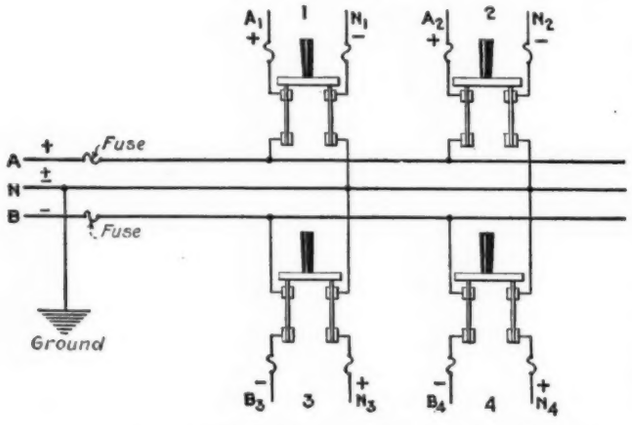


DIAGRAM OF TWO-WIRE CIRCUITS TAKEN FROM THREE-WIRE SYSTEM

grounded neutral, as in Fig. 1. Here the neutral *N*, which is the line grounded at the power station, is at an intermediate potential between the outside lines; that is, it is — with respect to the + line *A* and at the same time is + with respect to the — line *B*. Now when branch circuits, such as 1, 2, 3 and 4, are connected to such a system, each line of the branch circuits will have the same polarity as the corresponding main to which it is connected. Thus in branch circuit 1 the line A_1 will be positive and the line N_1 which is the grounded neutral, will be negative; and the same comments apply to branch circuit 2. However, in branch circuits 3 and 4, on the other side of the system, it will be noted that the grounded neutral lines N_3 and N_4 are positive with respect to the outside lines in each case. A brief survey with a voltmeter will illustrate this point further.

It can therefore be said in general that for three-wire direct-current systems the grounded neutral will be the negative line of all branch circuits connected to the + side of the system, but will be the positive line of the branch circuits connected to the — side of the system.

Small brass parts can be cleaned by heating slightly and then dipping them in solution of sal ammoniac.

Improved Type of Control Valve for Sewage Ejectors and Traps

A new type of control valve, adaptable for installation on steam traps, sewage ejectors and similar apparatus, has been developed by B. F. Bonner, of 296 Broadway, New York City. Its principal features are

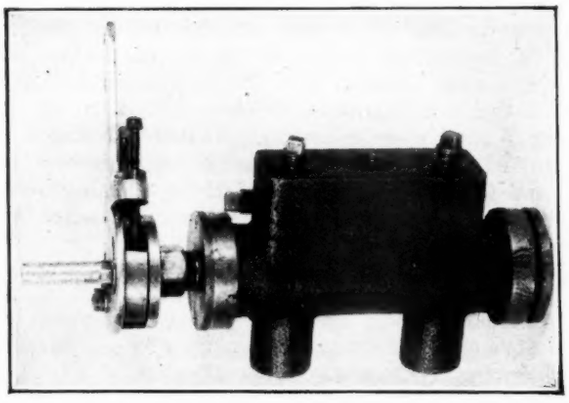


FIG. 1—GENERAL VIEW OF VALVE ASSEMBLY

that it is positive in operation and by virtue of its design is easily operated and the possibility of leakage is reduced to a minimum.

A general view of the valve is shown in Fig. 1 and a section in Fig. 2. It consists essentially of a cast-iron body and rotating plug fitted with an adjustable lever for connecting to a float in the discharge chamber or other operating device.

The design of the valve and method of operation will be clearly understood by referring to Fig. 2. The port *A* is connected with the steam or air pressure as the case may be, while the port *D* is left open to the atmosphere. When the plug *E* is revolved by the action of a float or other means, the relief port *C* is first closed, and when the plug *E* has revolved a certain amount, the pressure is admitted to the discharge chamber

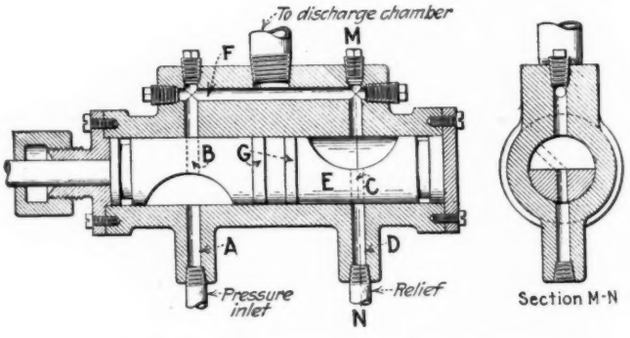


FIG. 2—SECTIONAL VIEW, SHOWING PRINCIPAL OF OPERATION

through the ports *B* and *F*. When the action of the float is reversed, *B* is immediately closed and *C* is opened to the atmosphere. The valve is sealed against leakage between the two ports by the rings *G*.

The operating lever is made adjustable by employing two movable blocks and one stationary block, the stationary block being attached to the valve spindle. In this way the valve can be regulated to meet practically any condition or different lengths of float travel.

EDITORIALS

F. R. LOW, EDITOR

Corrosion of Turbine Blading

MANY causes have been assigned to the corrosion of turbine blading. The general opinion has been that oxygen in the feed water has aggravated and accelerated this corrosion, for it seems to occur principally in the low-pressure blading where the steam becomes wet from expansion. Engineers are hoping that the deaërators now being installed in many plants will do much to prevent corrosion from this cause. These deaërators have not been used long enough to tell whether they will achieve this result.

Turbines have been known to corrode badly when standing still. This is partly due to the fact that the casing often remains full of steam when the turbine shuts down and this steam condenses, largely on the low-pressure blading, since this is at a low temperature when in operation, as for instance with a 29-inch vacuum. Frequently, when turbines are opened up beads of water will be seen clinging to the blades of many low-pressure rows.

Throttle valves are hard to keep tight, particularly with high superheat. Leakage through these valves into a standing turbine furnishes the moisture necessary to start corrosion. Special precautions must, therefore, be taken in stations using high pressures and superheats to prevent such leakage, at the throttle. A prominent British engineer recently stated that most of the corrosion troubles on turbine blading was due to leakage of the throttle valve when the turbine is standing still.

A novel plan is being tried out in one of the large foreign central stations. When a turbine is shut down, the air pump is kept running until the turbine stops, and care is taken to remove all steam from the casing while it is still warm. Two stop valves are placed in the main steam line before the turbine throttle, and these are both closed. An opening is provided between these two valves to a steam line at atmospheric pressure, which leads to an open heater. Leakage into the turbine is thus prevented and corrosion is said to be decreased. At the same time use is made of the heat in any steam that may leak past the first valve instead of allowing it merely to heat the turbine casing and the condenser, often with undesirable effects besides corrosion. This plan has some obvious merits and deserves consideration where throttle leakage has occurred or where high pressures and superheat will be used.

Thirty-two Hundred Pounds Steam Pressure

A FEW months ago we heard of a Swedish boiler designed for a steam pressure of 1,500 pounds per square inch. Now comes 3,200 pounds—this time from "conservative" England! This is sensational news, and as such will attract the man in the street as well as the engineer. But the engineer will not be content to sit in wonder at this latest marvel; he will immediately ask two questions: "Will it work?" and "Will it pay?"

The final answer to these questions can be given only after extensive practical experience with such pressures. What can be said now is that computations made by engineers experienced in power-plant design point to increasing commercial economy with increased pressures up to a point lying somewhere between 800 and 1,500 pounds. It is not generally claimed that anything will be gained by going beyond 1,500 pounds until it becomes feasible to raise the steam temperature well above 800 degrees F.

What, then, is the present justification for generating steam at 3,200 pounds, as is done in the Benson system described in this issue? The answer given is that it is easier and safer to generate steam at 3,200 pounds than at 1,500 pounds. This claim seems to accord with what is known about the properties of steam at extremely high pressures. It is well established that water has a "critical point" in the neighborhood of 3,200 pounds pressure and 706 degrees F., and that at this point the fluid slips quietly, and in mass, from the liquid to the vapor state without ebullition (boiling or bubbling). For this reason priming difficulties, which normally increase when the pressure goes up, may be expected to disappear at the critical point. This in turn should make it feasible to eliminate all large drums and generate the steam in coils of small-bore tubes such as can easily be built to withstand the critical pressure and temperature. The steam having thus been generated without difficulty at the critical point, could easily be throttled down to any desired working pressure. In the case of the experimental Benson plant this pressure will be 1,500 pounds at the turbine inlet.

It is evident that the theoretical efficiency of such a plant is exactly the same as if the steam had been originally generated at 1,500 pounds. The commercial success of the Benson steam generator must therefore hang on the proposition that steam for high-pressure plants can be most safely and cheaply generated at the critical pressure. The completion and testing of the 1,000-kilowatt experimental plant in the works of the English Electric Company at Rugby will be awaited with keen interest by all engineers interested in the generation and utilization of high-pressure steam.

The "Odd-Minute" Engineer

A SHORT time ago a writer in one of the farm magazines told of a man who had been highly successful in farm management. When a neighbor was asked the secret of the man's success, he replied that he was an "odd-minute farmer." When further questioned as to what he meant by this term, he explained that the man was never idle a moment. If he had a few minutes of spare time before dinner or supper or at any other period of the day, he always busied himself with odd jobs, of which he had an ample reserve store. He tightened a nut on a mowing machine there, or he nailed down a loose board on the

side of the barn here, or he did countless other little things that in the end served to keep his property, his stock and his equipment in first-class condition. If a man does all this, he is well started on the road to success as a farmer.

If we can have the "odd-minute farmer," then why not "the odd-minute engineer"? Why should not the same success result from applying this time-and-equipment-saving principle to engineering as resulted when it was applied to farming? It should and it does so result.

Let us see what the "odd-minute engineer" can find to do in these golden moments that are scattered along his otherwise oily and greasy path. And now we have in mind the under-man in the power plant rather than the Chief. We all know that the Chief always has a supply of mental problems concerning the welfare and management of his plant, that will occupy any odd minutes that may come his way. Though his hands and his body may be at rest, his brain is not.

It is the oiler, the fireman or the watch engineer who can use the odd minutes to greatest advantage. One man in mind, who later became a chief engineer, always carried about with him a polishing cloth. No oil or grease was permitted to remain on any polished metal work, or in fact on any of the equipment that came under his care. Small matter—you say! Perhaps that is true, but the machinery that was under that man's care was always clean. The main point was, however, that it evidenced the man's desire to make good use of his spare time.

There are gland nuts to be tightened to stop that leak; there is a bit of pipe-covering to be replaced; that small valve needs packing if the pressure can be shut off; there are spare gaskets to cut for use when needed in repacking valve bonnets on large engines; there is a new handle to be put in that peen hammer that was broken yesterday; there is a cold chisel with a broken edge from which a piece flew off earlier in the day and nearly ruined the eye of the man who was using it; and last but not least, there is the instruction and information to be obtained from reading the technical journals which the Chief leaves out on the table for the boys to look over if they care to do so.

These are but a small fraction of the many things that the power-plant man can find to do in his odd minutes; their number is legion. In engineering, as in farming, the man who makes the wisest use of his spare moments is the one most likely to succeed.

High Cost of Low-Head Water-Power Developments

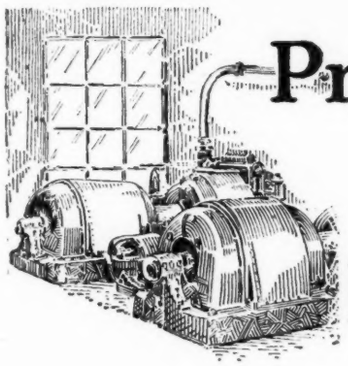
WHERE the head is low or the flow varies through wide ranges water-power developments are frequently uneconomical because of the high cost involved. Where both of these occur in the same installation, as in the case of the Green Island development of the Henry Ford & Son, Inc., near Troy, New York, the possibilities of making the project a commercial success is greatly handicapped. In this development, described in this issue, the head varies from practically zero to seventeen feet and the flow from 2,000 cubic-foot-seconds to a maximum of 250,000. Furthermore, the extreme low head is due to high water, so that when water is available to develop the full capacity of the plant, the head may be so low as to make the turbines inoperative temporarily. In addition to the difference in head due to variations in river flow, there is a tidal influence below the dam of about four feet maximum. More difficult hydraulic conditions could hardly be imagined for power development, and if it were not for recent improvements in the design of waterwheels and their settings, it is doubtful if this development could have been made a success.

A number of the dimensions for the turbine settings and intakes in this plant are considerably larger than similar dimensions in the Queenston plant at Niagara Falls of the Hydro-Electric Power Commission of Ontario. In the Ford plant turbines are rated at 2,000 horsepower and are of the high-speed propeller type; in the latter plant the units are rated at 55,000 horsepower, are of the Francis type and operate under a head of over three hundred feet. The bottom of the draft tube in the Green Island plant is forty-eight feet in diameter, with the horizontal center line of the turbine gates about thirty-three feet above the bottom of the draft tube; in the Queenston station the diameter is forty-two feet, with the center line of the turbine about thirty feet above the bottom of the draft tube. In both plants under full-load conditions and normal head the turbines pass approximately the same amount of water; namely, 1,750 cubic feet a second. The concrete intake to the penstocks of the Queenston turbines consists of three openings twelve feet eight inches wide; the intake to the Green Island turbines are four openings of the same width.

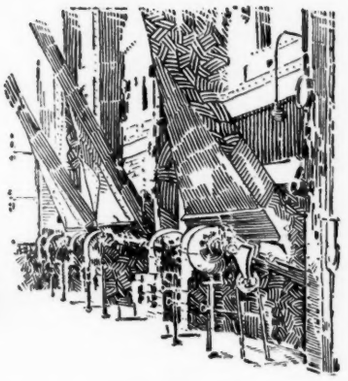
The Green Island runners are thirteen feet in diameter compared to ten feet five inches for the Queenston. In the former the runners are of the high-speed propeller type operating at eighty revolutions per minute, whereas if Francis-type runners had been used the speed would have been less than one-half that of the propeller type. What the effects of reducing the speed might be is shown by the Francis-type runners installed in the Cedars development, near Montreal. In this installation the head is thirty feet, requiring a runner seventeen feet in diameter for ten thousand horsepower and weighing about ninety tons; in the Green Island installation the runner weighs less than one-tenth of this and is of comparatively simple construction. Although there are other factors that enter into the cost of high- and medium-head plants, such as canals, tunnels, penstocks and penstock valves and weights to be supported on the superstructure, the foregoing shows that the low-head installation is necessarily expensive.

Difficulty in controlling steam temperatures under variable load conditions is a problem confronting the operating departments of many stations. We have it on good authority that steam temperatures in one station, designed for operating at six hundred and fifty degrees, recently ran to eleven hundred degrees for a considerable period. That the valves and fittings stood up under such conditions is most creditable. Another large station designed for seven hundred degrees has been running at times over eight hundred degrees without disastrous results. Nevertheless most power-plant designers, although now favoring higher pressures, are conservative as to temperatures.

In the description of the Green Island hydro-electric plant acknowledgment to Mr. F. Nagler was inadvertently omitted. Mr. Nagler was responsible for the design of the runners and much of the hydraulic layout and supplied most of the information pertaining to that part of the plant.



Practical Ideas *from* Practical Men



Some Troubles Experienced with Steam Pumps

A steam pump is generally looked upon as a simple piece of machinery, and as long as it keeps running and gives no trouble, little thought or attention is given to it. But simple as it appears, it takes comparatively little to derange its action, and it sometimes presents puzzling problems to the engineer.

My first case of pump trouble was caused by packing a flanged joint in the discharge pipe and forgetting to cut the center out of the rubber gasket. As the pump had not been in use, of course I looked everywhere else for the trouble before breaking that joint again. Finally, after considerable work and worry (I was just a beginner then), I discovered my mistake.

At another time a duplex oil pump lost its suction and I was unable to get it to pick up the oil again, and even though the suction line was then filled with oil up to the pump, it would not take hold. The pumps had a long suction pipe, which should have been a size larger, and it sometimes became vapor-bound, but opening the valve in the gas-relief pipe had always corrected the trouble before. Going over all the valves, I failed to find anything wrong, so I concluded that the gas-relief pipe must be plugged. The pipe was then examined and found to be plugged at a bend; this had made it impossible to relieve the pump.

When changing over to another boiler-feed pump one day, I found, upon trying to start the pump, that it did not have power enough to pump against the boiler pressure. Removing the steam chest cover, I found one side of one of the valves resting on a ledge, which held it off its seat. This had allowed steam to blow through to the exhaust. When this pump had been stopped last, the valve in the exhaust pipe had not been closed, and as the other pump was exhausting into an open feed-water heater against a back pressure of 4 or 5 lb. gage, the exhaust-steam pressure acting under the valve of the idle pump had thrown it up and it had caught on the ledge

Another time one of these pumps had been stopped a short time, and upon attempting to start it again, it appeared to be steambound. As no relief valve was provided, there was no way of getting rid of the steam in the water cylinders. After working with it a little while without success, I tried to start the other pump, but it was in the same condition and all that either one of them would do was to slam back and forth and cause the water in the heater to surge up and down. After some deliberation I closed the glove valves and opened a check valve until the pump took water. I concluded that the trouble was caused by water from the boilers leaking back past both check and pump valves while the pump was stopped, to the suction side of the pump, where, owing to the reduction in pressure, part of the high-temperature water flashed into steam and thus prevented the pump from taking water.

Where a pump is required to handle hot water from an open feed-water heater, the heater should be installed several feet above the level of the pump, so as to give sufficient head to cause the water to follow up the piston on its suction stroke and completely fill the cylinder. When the water in the heater is heated to nearly the boiling temperature, the reduction of pressure due to the pump suction will cause the vaporization of some of it and the cylinder will be only partly filled with water, and the piston will jump at the beginning of each stroke, unless the water has sufficient head to overcome this effect. This is especially true in case the pump is required to run fast or the suction pipe is too small.

Such troubles as foreign matter getting under a pump valve or a valve coming loose, which causes the piston to make a quick stroke one way and piston packing to give away, and necessitates speeding up the pump to make it handle the normal amount of water, are troubles familiar to all who handle pumps. H. G. ROBERTS.

Seattle, Wash.

Reminiscences of the Old Todd & Rafferty Engine and Holland's First Submarine

In the latter part of the summer of 1888 (about two years after my advent in the engineering line), I obtained a position in the machine shop of James Dunkerly & Son, corner of Grand and Spruce Sts., Paterson, N. J.

The Dunkerly establishment was, I believe, one of the oldest of its kind in the City of Paterson, having been founded in 1856 by James Dunkerly, Sr. It was in this shop that I saw one of the original Todd & Rafferty engines. This engine was, I understand, first built by T. C. Simonton and was exhibited at the Crystal Palace, New York City, in 1842. I believe there were quite a number of these engines in use at one time, and I recall several of them that were still running not so many years ago.

The engine in question had a rather eventful career; as it was later installed in a soda water manufactory, where one day, owing to the governor's failing to function, it ran away and the flywheel burst. Through this and a fire that followed, the plant was badly wrecked. The engine was later purchased by Mr. Dunkerly, and after a new flywheel was procured, it was set up and furnished power to operate the Dunkerly shops until the early 90's, when, after being replaced by a Corliss

engine, it was, I believe, sold to the Broomhead Mills, of Paterson.

The general design of the Todd & Rafferty engine was as follows: The bedplate was of the box pattern, to the top of which were attached the cylinder, guides, main bearing pillow block, etc. The steam chest was on top of the cylinder, and the slide valve received its motion through a rock shaft, bell crank, and swing arm, to which the eccentric rod was attached. It was built at the old Todd & Rafferty machine works in Paterson.

It was in this same shop that parts were made for John P. Holland's first submarine. That was in 1876, and it was launched in the Passaic River, just above the falls, in 1878.

Many jobs were handled by this firm, covering quite a varied field, and while I was with them they had considerable to do with the fitting up of one of the first ice plants in the City of Paterson. G. J. LITTLE.

Hasbrouck Heights, N. J.

Armature Testing Device

Electrical repair men have many kinds of devices for testing direct-current armatures, but the one shown in Figs. 1 and 2 can be carried in the vest pocket and is used for making contact with the commutator to pass a current through the winding when making a test. From a piece of $\frac{1}{4}$-in. fiber cut two pieces $\frac{1}{2}$ in. wide by 1 in. long, as at *A*, Fig. 1. Drill a $\frac{1}{16}$-in. hole $\frac{3}{16}$ in. from the ends of each piece, and then with a hacksaw cut two slots $\frac{1}{16}$ in. deep in one of them, parallel with the holes but $\frac{1}{4}$ in. from the ends, as shown at *B*. In piece *B* also drill two more $\frac{1}{16}$-in. holes near the others, as indicated. Drill a hole through the center of each one for a No. 6-32 or 8-32 by $\frac{3}{4}$-in. round-head bolt as in the figure. The bolts are fastened tightly in the holes with a nut, and

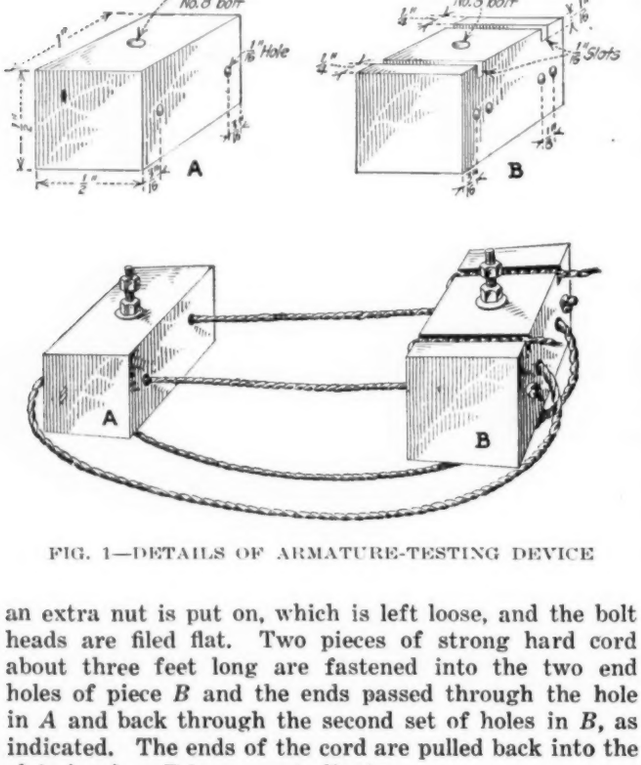


FIG. 1—DETAILS OF ARMATURE-TESTING DEVICE

an extra nut is put on, which is left loose, and the bolt heads are filed flat. Two pieces of strong hard cord about three feet long are fastened into the two end holes of piece *B* and the ends passed through the hole in *A* and back through the second set of holes in *B*, as indicated. The ends of the cord are pulled back into the slots in piece *B* to prevent slipping.

When testing an armature, this device is placed around the commutator as in Fig. 2 and the cord pulled tight. Piece *A*, being free on the cords can be adjusted to bring the contacts the proper distance apart on the commutator and the current leads attached. When the current has been adjusted to the proper values, the

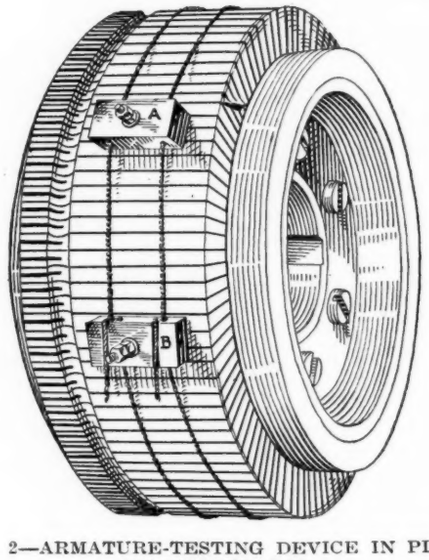


FIG. 2—ARMATURE-TESTING DEVICE IN PLACE ON COMMUTATOR

workman is free to go ahead to make his test with low-reading voltmeter on telephone receiver.

Teaneck, N. J. HENRY KLEIBER.

Diesel-Engine Compressor Valves

At least three-fourths of the trouble with Diesel compressors is in the high-stage valves, the discharge valves usually being the ones that start leaking. I test the feather-type valves used on the Diesels I am operating, by placing the cage with the valve strips in place on a table and filling the discharge side of the cage with kerosene. If the rate of leakage is not more than four drops a minute, the valve strips should work all right. About 50 per cent fail to do so on account of the feather not being permanently seated.

After this valve has been assembled and replaced in the compressor in the regular way, the suction valve on the opposite side of the compressor should be removed. One is now able to see the cylinder side of the discharge valve if the piston is not too near the head. Air pressure is put on the back side of the discharge valve by opening the globe valve that is used to charge the storage tank. Next one end of a $\frac{1}{4}$-in. rod about 12 in. long is placed in one of the holes in the discharge-valve seat and is tapped hard enough to raise the feather strip off its seat. It is sometimes necessary to raise the feather $\frac{1}{8}$ in. to get it to stop leaking. If this is done a few times, the feathers will become well seated and trouble with this valve is over.

In using any lubricant more volatile than cylinder oil on these valves one should be sure to clean the strips thoroughly before putting them in service, or an explosion is liable to wreck the machine.

If trouble is experienced with the gasket between the valve cages and the head, grinding them to a seat just as one would engine air or exhaust valves will eliminate the leak. FRED ENGLAND.

Ranger, Tex.

Comments from Readers

Repairs Under Pressure

In the March 20 issue there appeared an article entitled "Repairs Under Pressure." I never looked with favor on this method of repairing a leaky pipe joint, but it can be tolerated in some instances.

In my opinion the type of clamps as ordinarily made are dangerous and should never be manufactured, much less used. I refer to clamps that fasten to the pipe by setscrews or otherwise. These clamps should be fastened to the flange or fitting against which they are supposed to hold the packing material. There can then be no possible jacking effect tending to pull the pipe out of the fitting such as must occur when the clamp is fastened to the pipe and the packing material forced against the fitting by setting up on the setscrews provided for that purpose.

Any ordinary mechanic would know this type of clamp would place an additional stress on the threaded joint if he only gave it a thought. But the fact that these clamps are put on the market by reputable firms causes many men to install them on leaky joints without giving the possible consequences any consideration.

Hamilton, Ohio. JOSEPH STEWART.

Operation of Series Generators

In the article, "Motorizing Electric Generators," in the April 24 issue, Peter G. Dahl explains the action of single-, two- or three-phase alternators and shunt-, series- and compound-wound direct-current generators, in case one of the machines normally operating in parallel with others is motorized owing to failure of its driving power.

It is quite improbable that a condition would arise in which it would be practical or advisable to operate series-wound direct-current generators in parallel. The inherent characteristics of a series generator are such that it is essentially a constant-current machine and is unsuited for constant-potential work. As a constant-current machine it has been applied to street-lighting service and in the early days of electrical development was often used for driving small motors from the series arc circuits. In a few instances, notably in Europe, series direct-current generators have been used in power-transmission work of considerable magnitude, supplying constant current to receiving devices usually consisting of large motors or motor-generator sets which in turn furnish constant-potential current for local distribution.

Since the only practical application of the series direct-current generator is as a constant-current machine, the only system developed for operating two or more such machines on the same circuit is by connecting the various machines in series, all supplying the same fixed current at a line voltage determined by the requirements of the load on the receiving circuit.

With series-connected direct-current series-wound generators, should the driving power of one of the machines fail, the results would be the same as Mr. Dahl explains for the case of parallel-connected machines of this type; that is, the machine would come to rest and then start as a motor in the reverse direction of rotation unless prevented by protective devices.

With series machines connected in parallel, should one become motorized, the direction of current flow in both the field and armature windings would reverse, while with similar machines connected in series the current in both field and armature windings of the motorized machine would of necessity continue to flow in the same direction as when operating as a generator. However, the effect in both cases is the same, inasmuch as the relation of the field and armature current remains unchanged, so that the mechanical force exerted by the field on the armature is unchanged in direction when the function of the machine is changed from generator to motor. J. H. BENDER.

Crosbyton, Tex.

Steam-Boiler Fittings in Holland

In connection with the proposed A.S.M.E. rules for piping and fittings (published on page 702, Oct. 31, 1922, issue) I wish to submit the following:

According to our national steam boiler rules the installation of blowoff piping made of wrought iron is prohibited. Soft steel or copper should be used. Blowoff cocks and valves, and feed cocks or feed valves should be made of brass. In Germany, however, the rules for blowoff and feed cocks and valves conform to the A.S.M.E. Boiler Code. Safety valves are computed according to the formula.

$$M = 26\sqrt{\frac{W}{d + 0.62}}$$

where

M = Diameter in millimeters;
W = Heating surface in square meters;
d = Steam pressure in kilograms per square centimeter absolute.

If the diameter of the valves appears too small in the opinion of the boiler inspector, an accumulation test (see Par. 391, A.S.M.E. Boiler Code) can be made. In that case the inspector will approve the valves when the gage pressure after twenty minutes indicates a pressure rise of less than 10 per cent of the normal pressure.

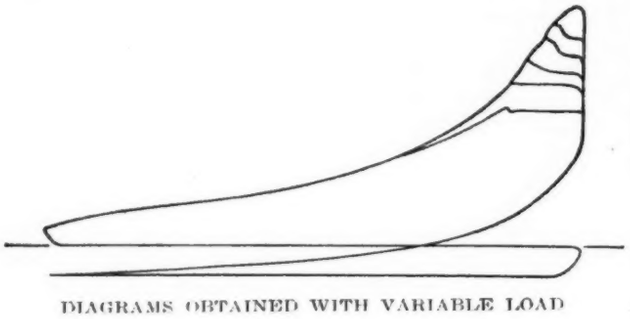
Although Professor Dyxhoorn, of the University of Delft (Holland), proposed many years ago a set of rules for the design and construction of steam boilers, the manufacturers in this country work to their own individual specifications.

Accidents in connection with the operation of boilers are exceptions in this country, and this I ascribe chiefly to the low pressures, conservative ratings and, last but not least, to the rigid governmental supervision to which all boilers are subjected. Until recently this service was rendered free of charge, but next year the owners will have to pay a small fee. H. WIELAND LOS.

Schoonhoven, Holland.

Diagram from a Blast-Furnace Gas Engine

The indicator diagrams shown herewith may prove of interest to *Power* readers who operate gas engines. They were obtained from a 48x60-in. engine connected



DIAGRAMS OBTAINED WITH VARIABLE LOAD

to a 3,500-kva. generator and operating on blast-furnace gas.

I should like to have some criticism on these diagrams from readers of *Power* who operate engines of this kind.

A. FRITZ.

South Chicago, Ill.

Combustion Control for Steam Boilers

I have read Mr. Smoots' article in the issue of March 6 with considerable interest and believe it is a subject worthy of full discussion. The editor's note inviting this discussion, states in part as follows:

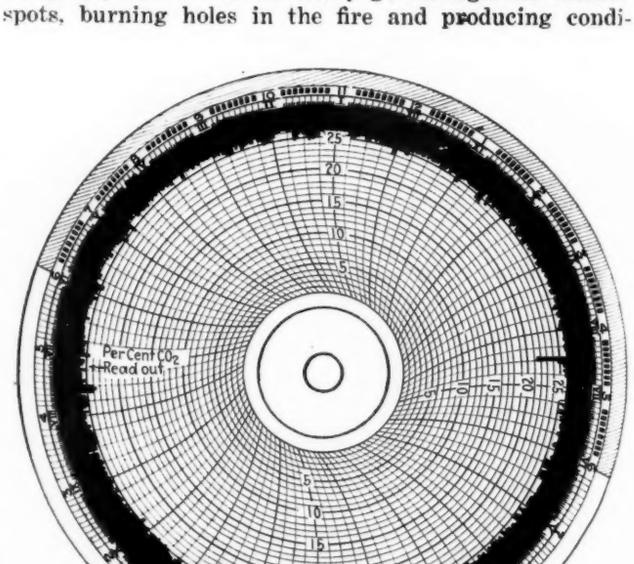
> The efficient control of combustion with widely varying loads is by no means a simple problem and is one on which a great deal of development work has been done during the last few years, and much progress has been made. However, a great deal more will have to be done before a complete solution of the problem is obtained.

The statement is undoubtedly correct, but it leaves the burden of further development up to the engineer, who is studying the control problem and does not differentiate between the problems that come within the scope of combustion-control apparatus and those that are brought about by the imperfections of the apparatus it must control.

As an illustration of the extent to which automatic control equipment has been developed, the attached chart, showing a 24-hour record from a CO_2 recorder, is presented. This chart was taken from a plant burning blast-furnace gas, which was delivered to the burners in widely varying quantities entirely beyond the control of the operator. It was necessary to take whatever gas was delivered and burn it as economically as possible. The variations in combustion rate were at least as great as those necessary in a boiler plant carrying a highly fluctuating load, and it shows what can be done in the way of combustion control of widely varying rates of combustion, which is merely another way of stating "a widely varying load." An average analysis of from 24.5 to 25 per cent CO_2, ½ per cent to 1 per cent oxygen and no CO, under these conditions, represents excellent combustion control, and shows what automatic equipment can do when provided with the right conditions.

Such results cannot be secured in the automatic control of mechanical stokers—not because the control equipment is imperfect, but because of the performance of the stoker itself. The only manner in which control apparatus can regulate the rate of coal supply to a furnace is by regulating the speed of the stoker, and no stoker will feed a weight of coal bearing a direct relation to its speed. The percentage of fines in a coal will affect the weight per cubic foot, and even if the stoker puts in the right number of cubic feet, it will not put in the correct weight. The moisture content of the coal also affects the weight per cubic foot and again affects the weight delivered by the stoker for a given speed. Coal that carries a considerable percentage of fines, such as that commonly burned on stokers will weigh as much as 10 per cent less per cubic foot when it carries 4 per cent or 5 per cent surface moisture than when free from surface moisture. There will, therefore, be a difference of 14 to 15 per cent in the actual weight of fuel delivered for a given stoker speed, even assuming that the coal is all of the same general quality and carries about the same B.t.u. per pound, dry. It is too much to expect of automatic control apparatus that it will correct for such conditions.

In the case of oil, gas or powdered coal it is possible to get through mixing of the fuel with the air supplied for combustion, but this cannot always be done with mechanical stokers. Clinker formations in the fuel bed or along side walls or bridge walls produce irregularities in the fuel bed, for which regulating apparatus cannot make corrections. It is possible to feed the exact quantities of coal and air to a furnace in the right proportion for best economy, and if the fuel bed is irregular, the air will naturally go through the thinner spots, burning holes in the fire and producing conditions of low efficiency, because the air that is being delivered is not completely mixing with the fuel that should be burned, and as a result the rate of combustion drops and the fuel begins to pile up at those points where air is not passing through it freely.



TWENTY-FOUR-HOUR RECORD FROM CO_2 RECORDER

Combustion-control equipment is limited in the results secured by these imperfections of mechanical stokers, and it is for this reason that it can never completely replace a skillful stoker operator. It can, how-

ever, be of valuable assistance to him, and not only can materially reduce the amount of work he must do, but will enable him to secure, day after day, better results than can be had without automatic control. Fluid fuels of all kinds, including powdered coal, do not impose such limitations on automatic control, and much better control can therefore be expected. As the commercial use of powdered coal in boiler plants increases, the very fact that it is much more susceptible to accurate automatic control than the mechanical stoker, is going to be recognized as one of the important advantages and one which in many cases will determine the selection of equipment in favor of powdered coal.

T. A. PEEBLES, Chief Engineer.
Pittsburgh, Pa. The Hagan Corporation.

Large Percentage of Impurities Passes Over with the Steam

I should like to add further to the comments made by O. R. McBride in the April 10 issue on "Large Percentage of Impurities Passes Over with the Steam."

The average boiler tends to throw anywhere from ½ per cent to 3 per cent or more of moisture into the steam header. This moisture, which is a mechanical carry-over of water with the steam vapor, contains in solution and also in suspension its proportion of the salts and impurities in the boiler. It is these impurities that cause turbine-blade erosion, clogging of superheaters, scoring of engine cylinders and valves, clogging of traps, steam-flow meter leads and the like. Evidence of impurities going over with the steam are common, and most engineers are familiar with the disastrous effects of impurities in clogging valves and decreasing pipe sizes, to say nothing of the major loss caused by such impurities in erosion of prime movers and decreasing of efficiency.

If the moisture content in the steam leaving the average boiler were pure distilled water, engineers would have little cause for worry, as the superheater would either evaporate that water or it would simply go along as an inert body, doing no harm. But it is the impurities in that water which cause operating difficulties. For instance, in one plant that I am familiar with, the sodium sulphate carried over with the steam eroded the main turbine so badly in less than two months' operating time that it had to be rebladed completely. In other plants known to me the impurities carried over with the steam from the boilers constitute one of the worst operating problems that the engineers have to contend with. It is because of the steam carrying impurities from the boiler that at the present time radically different dry-pipes or "steam purifiers" are being widely used, as with such steam purifiers the moisture and dirt are mechanically removed from the steam before it leaves the boiler drum. R. W. ANDREWS.
Pittsburgh, Pa.

Mr. McBride's experience compares favorably with my own. In my present plant there are a large number of expansion joints, some of them a considerable distance from the boiler room. Whenever these joints develope a leak and require repacking, the sleeves are always found coated with a thin coat of hard scale. The boilers supplying steam to this system do not prime and the water level is not carried above the second gage cock. Moreover, no scale ever forms in these boilers, although considerable soft sludge is found in them after a run. This sludge is fine-grained and is pink in color and in no way resembles the hard gray scale found on the expansion-joint sleeves.

It is my personal opinion that the scale is due to a small amount of water being carried over with the steam, and that the soluble impurities contained in this water are deposited upon the expansion-joint sleeves, owing to the re-evaporation of the moisture which occurs because of the drop in pressure from that of the line to atmosphere. When these joints are repacked, the scale is removed and a coat of cylinder oil and graphite is applied to the new packing and also to the sleeve of the joint. This makes the removal of the next coat of scale much easier. A. C. MCHUGH.
Norwalk, Calif.

I was interested in Mr. McBride's letter, as it recalls some of my earlier experiences.

In 1900, after an experience in an official capacity at the Hewes & Phillips Iron Works, Newark, N. J., the gist of this topic was put in plain and few words and I well remember my pert reply to the president of that concern: "Dirty steam."

Finally, on Aug. 13, 1904, patent No. 768,190 was issued to me on a method of purifying the steam before it leaves the boiler. JAMES NAYLOR.
Arlington, N. J.

Exhaust Piping of Internal-Combustion Engines

In the May 1 issue of *Power* appeared a comment by Douglas P. Muirhead, of Glasgow, Scotland, on the increase of the power of a semi-Diesel engine by a change in the exhaust pipe. He maintains that the gain in power cited by M. S. Howe in *Power*, Feb. 27, was due to a partial vacuum being created in the exhaust line and thus scavenging was more complete. Neither stated what it would cost in fuel to produce this gain in power.

I know of a couple of instances where a partial vacuum was considered to be an advantage. The first case was where an ejector exhaust manifold was so arranged that at the end of the exhaust stroke of one cylinder the next exhaust valve would open and the products leaving it caused a violent suction on the one about to close. This idea was patented, but only one of these engines was ever built, for the price was too great, and a little later this concern failed and quit.

The second instance was with a large two-stroke-cycle gas engine where an excess of exhaust-port lead resulted in a decided drop below atmospheric pressure, as shown by an indicator diagram. The fallacy of the design was quite evident, and its value is not recognized since the price of gas is high.

In a two-stroke-cycle gas engine any tendency toward creating a partial vacuum simply proves the exhaust-port lead over the inlet or transfer port is excessive and there is no gain from this. Such a condition is a defect because the area of an indicator card at the toe is reduced, and so is the power output. Second, the lag due to exhaust-port closure reduces the effective stroke during the compression stroke and loss of mixture in engines using it.

In a semi-Diesel excessive exhaust-port lead is equally bad; even if an indicator diagram shows a decided drop below atmosphere, it is of no value from a power or economy point of view. JAMES MCINTOSH.
Cleveland, Ohio.

QUESTIONS AND ANSWERS

Conducted by Franklin VanWinkle

Detecting and Correcting Loose Boiler Rivet

How can looseness of a boiler rivet be detected and how can it be corrected? M. H. P.

A person experienced in making hammer tests usually can detect the presence of loose rivets in an empty boiler shell by striking the shell with a sounding hammer. Looseness of a separate rivet can be determined by pressing the end of the second finger of one hand on the rivet head while exerting the same pressure on the ends of the first and third fingers of the same hand held against the shell on each side of the rivet. A loose rivet will be revealed by a marked difference in feeling of the vibrations when the shell is struck a sharp hammer blow in the vicinity of the rivet. Looseness of a rivet in the shell usually is revealed by leakage.

In any event a loose rivet should be cut out, and after the rivet holes are reamed fair, a hot rivet should be driven to fill the hole solidly. Leakage at a rivet sometimes may be stopped by calking, but when it is due to looseness at the rivet shank, the calking cannot be kept tight permanently.

Temperatures for Testing Viscosity of Oils

What should be the temperature of oils in making viscosity tests? S. L. G.

Standard temperatures accepted for viscosity readings are: Turbine engine and machine oils, 100 deg. F.; steam cylinder, car oils and gear oils, 210 deg. F.; motor oils for internal-combustion cylinders, 100 or 210 deg. F. However, oils having the same viscosity at one temperature may not be the same at other temperatures. The temperature during the viscosity test should be at or near the temperature at which the oil is to be used. So-called dynamo and machine oils usually are to be tested at 70 deg. F. and again at 120 deg. F., which is the temperature of a bearing that is running quite warm. Cylinder and gas-engine oils should be tested at 100, 200 and 300 deg. F., or for internal-combustion engines or engines using superheated steam the viscosity should be determined at still higher temperatures.

Advantages and Disadvantages of Operating Condensing

What are the advantages and disadvantages of operating a reciprocating engine condensing? A. D.

The advantages of operating condensing are reduction of the back pressure, thereby increasing the power output of a given engine for a given amount of steam or decreasing the necessary size of cylinder for a given power output for less steam; and as heat that otherwise would be wasted is converted into work, by operating condensing the steam consumption of large engines often is decreased 20 to 30 per cent, depending on working conditions. Other advantages are that most of the feed water may be recovered unless a jet condenser is used with impure water, and the recovered feed water usually is about 50 deg. F. warmer that the temperature of the fresh feed water available.

The disadvantages are: Requirement of additional equipment for condensing, pumping and recooling of fresh supply of cooling water; operation of the engine requires more skill and attention; no exhaust is available for heating; there are more joints to be kept tight and more equipment must be maintained than when operating non-condensing. In condensing plants where the auxiliaries are steam driven, their exhaust may be used to heat the feed water, and this lessens the disadvantage of the extra equipment.

Changing Alternating-Current Generator to Synchronous Motor

We have a 285-kw. 60-cycle three-phase alternator directly connected to a waterwheel, which at times operates in parallel with a 120-kw. machine driven by a belt from a lineshaft. This lineshaft is driven by a steam engine which supplies power for driving not only the generator, but also a number of manufacturing machines in the plant. At times the mechanical load on the lineshaft becomes too great for the steam engine, and the 120-kw. machine is then made to run as a synchronous motor and takes 120 kw. at unity power from the waterwheel-driven unit. To do this, the speed of the 285-kw. machine is increased to where the frequency meter reads 62½ cycles, and at the same time the engine speed is reduced to decrease the speed of the 120-kw. machine. It seems to me that there is too great a change in speed. Decreasing the engine's speed and that of the 120-kw. unit causes a serious loss of production. Why is there such a wide change in speed, and how can this be overcome? P. E. M.

Instead of the speed of the engine decreasing as supposed, it has actually been increased over 4 per cent. The speed of the 120-kw. machine running as a motor corresponds to the frequency of the waterwheel generator, which has been increased from 60 to 62½ cycles. If the 120-kw. machine has 8 poles, it will be running at 900 r.p.m. when generating 60 cycles, but if operated as a synchronous motor on a 62½ cycle circuit its *speed* $= 120 \times$ *cycles* $\div$ *number of poles* $= 120 \times 62.5 \div 8 = 937.5$ *r.p.m.* If the 120-kw. machine were operating under full load as a generator and were then converted into a motor operating under full load, the engine would be relieved of 240-kw. load or approximately 350 mechanical horsepower load, and this would cause considerable change in speed. Unless the waterwheel generator was operating under light load before the change was made, it is doubtful if it would take care

of this increase. As soon as the speed was increased on the waterwheel, its generator began to take load from the belted machine, which relieved the load on the engine and it began to increase in speed. If the speed of the system is to be held at a value corresponding to 60 cycles, the governor on the steam engine should be adjusted to cause the same tendency to decrease in speed as the waterwheel's governor is adjusted to cause an increase in speed. If the frequency of the system is held at 60 cycles, there will be no change in speed.

Copper Ball Pyrometer

A piece of copper weighing 1¼ lb. was suspended in the uptake of a boiler until the temperature was the same as that of the chimney gases. The copper then was removed and immediately plunged into 6 lb. of water at 76 deg. F., and the temperature of the water rose to 88 deg. F. Assuming that no heat was lost during the test, what was the temperature of the uptake gases? P. W. W.

The temperature of the gases would be given by the expression,

$$\frac{W(T - t)}{ws} + T$$

in which

W = Weight of the water, pounds;
T = Final temperature of the water;
t = Initial temperature of the water;
w = Weight of copper, pounds;
s = Specific heat of copper = 0.095.

Substituting the given values, the temperature of the gases is found to be

$$\frac{6\ (88 - 76)}{1{,}25 \times 0.095} + 88 = 694 \text{ deg. F.}$$

Location of Draft Gage Opening with Oil Burners

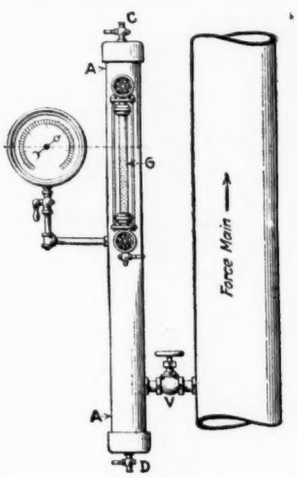
What is the proper place to put the pipe of a differential draft gage in a horizontal return-tubular boiler equipped with a mechanical oil burner—in the uptake below the damper or through the front in the firebox? W. R. M.

A simple draft gage indicates the difference in pressure between the point to which it is connected and the atmosphere. A differential draft gage indicates the difference in pressure between two points in the gas passages. A connection made through the front should extend to a point where it may be reasonably assumed that the pressure at the opening is representative of the whole cross-section of gas passage containing the opening of draft-gage connection. As mechanical oil burners are operated under pressure, there are irregular air and gas currents in the vicinity of the burner and for a considerable distance ahead of it. Hence, if one of the connections of a draft gage is made through the boiler front with its opening in the front end of the furnace space, the draft-gage readings would be of little use in analyzing the working conditions, on account of the uncertain influence of the burner. However, if the connection through the front or side of the setting opens into the first pass beyond the furnace space, the readings of a simple gage compared with readings of a simple draft gage connected with the uptake below the damper, or the direct reading of a differential draft gage connected at each of those places, would show the loss of draft pressure of the gases in their passage between these points.

Connection of Pressure Gage to Force Main

How can a pressure gage be connected to a force main from a pump for indicating the head pumped against and protect the gage from water hammer? L. F. S.

A small reservoir with an air chamber should be interposed between the gage and the force main. This, as shown in the figure, consists of a short length of 2-in. pipe AA, capped at both ends, connected to the force main with a stop valve V near its lower end and provided with a drain cock D, air cock C and glass gage G. Thus connected, the gage cock should be run wide open. By means of the cocks C and D the average water level in the glass gage can be adjusted to the height of the center of the pressure gage from which the pressure can be reckoned, or if not so regulated, the pressure gage readings must be adjusted to whatever its level may be. The air chamber formed in the upper part of AA will smooth out the pulsations of the pump, and any choking that may be found necessary for evener indication of the pressure gage should be done with the stop valve V.



AIR CHAMBER FOR PRESSURE GAGE ON FORCE MAIN

Tension of Vapor

What is meant by tension of a vapor or tension of a vacuum? J. M.

The term tension, as applied to a vapor, signifies the pressure that would be exerted per unit of area normal to the side of a containing vessel, as when gaged by the pressure exerted in pounds per square inch; measured by the height of a column of water that would be sustained; or, as usual for pressures below the pressure of the atmosphere, the tension may be gaged by the number of inches of mercury column that may be supported by the tension of the vapor. The term tension is commonly used by physicists to apply to individual pressure of gases or vapors mechanically combined with other gases or vapors, and the term pressure is more commonly employed with reference to the net force exerted on a unit of area of the containing vessel. The effect that tension of a vapor has on a space occupied by it, that otherwise would be a vacuum, is to produce pressure corresponding to the temperature at which the vapor is formed from its liquid. However, when any pressure is present, as from a vapor, there is not a perfect vacuum, because a vacuum is a space that contains nothing, which could not be the case if any vapor were present. But the expression vacuous space or simply vacuum is commonly used with reference to a space in which the pressure is below the pressure of the atmosphere, and "tension of a vacuum" is commonly used with reference to the absolute pressure of such a space.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses.—Editor.]

Easy Lessons in Engineering

The Slide Rule—II. Proportion; Squares and Square Roots; Cubes and Cube Roots

This is the second of two brief lessons on the use of the slide rule. The first which appeared in the previous issue, covered the following: Names of the parts of the slide rule, reading the *A*, *B*, *C* and *D* scales, multiplication and division on the *A* and *B* scales and on the *C* and *D* scales. The present article will cover proportion, squares and square roots, cubes and cube roots and areas of circles.

The solution of a problem in proportion is remarkably simple with the slide rule. To avoid running off the scales, we will use only the *A* and *B* scales for proportion. The principle back of the solution of such problems is that, for any position of the slide, the ratio of any number on the *A* scale to the one directly below it on the *B* scale is a constant all over the scales. For example, move the slide (see Fig. 1) until the index (1) of the *B* scale comes under 3 on the *A* scale. Then we find (shifting the decimal points where necessary as explained in the previous article) and 6 comes over 2, 9 over 3, 12 over 4, 15 over 5, 18 over 6, 21 over 7, etc. In each case the ratio of the upper number to the lower is 3.

Now a proportion is a statement that one ratio is equal to another, so for any position of the slide the numbers on one scale are in proportion to the adjacent numbers on the other. For example, the diameter of any circle is to its circumference as 1 is to 3.1416 (called "pi" and indicated by the Greek letter π on the *A* and *B* scales). This proportion may be written in several different ways. One would be:

1 : π :: Any diameter : Corresponding circumference

Again the ratios may be written as fractions and the proportion as one fraction equal to another. In this case we would write:

$$\frac{1}{\pi} = \frac{\text{Any diameter}}{\text{Corresponding circumference}}$$

This second method of writing a proportion is the best when using a slide rule, because it gives a picture of the actual settings. The positions of the numbers on the scales will be exactly the same as in the proportion. The numbers in the numerators will come on the upper scale and those in the denominators on the lower scale. Moreover, if the slide is so placed that 1 on the *A* scale comes directly over π on the *B* scale, any diameter read on the *A* scale will be directly over the corresponding circumference on the *B* scale.

In Fig. 2 the slide has been moved to this position. As long as it is not disturbed, we may imagine that the rule has become a table with the *A* scale labeled "diameters" and the *B* scale "circumferences." Having been given any diameter, the runner is moved to that point on the *A* scale and the corresponding circumference read directly below on the *B* scale.

If the diameter is 12.17, move the runner to 1.217 (*a*) on the *A* scale. Directly below on the *B* read 3.82. Since the actual diameter is about 12 and the circumference about three times as great (36), the circumference, correctly pointed off, should be 38.2.

If the diameter is 5.72, the circumference will be 18.0 as at (*e*). In the same way a diameter of 213.5 (*c*) gives a circumference of 670, and a diameter of 0.371 (*d*) gives a circumference of 1.165. The reverse operation is illustrated by *b* and *f*, the former showing that a circumference of 42.0 corresponds to a diameter of 13.38 and the latter that a circumference of 267 corresponds to a diameter of 85.0.

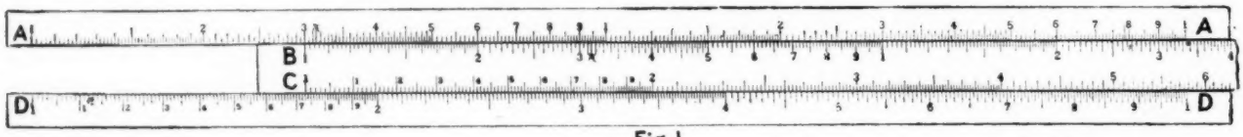


Fig 1

Fig 2

Fig 3

FIGS. 1 TO 3—HOW THE SLIDE RULE IS USED TO SOLVE PROBLEMS IN PROPORTION

The back of the rule usually gives a number of convenient proportions. For example:

$$\frac{\textit{U. S. Gallons}}{\textit{Cubic feet}} = \frac{800}{107}$$

To make a table for changing U. S. gallons to cubic feet or the reverse, move the slide until 800 (that is 8.) on the *A* scale comes directly over 107 (that is 1.07) on the *B* scale as at *e* in Fig 3. Then imagine that the *A* scale is labelled "gallons" and the *B* scale "cubic feet." The lines *a*, *b*, etc., indicate the solutions of the following problems, the decimal point being so placed

as to make the number of gallons about eight times the number of cubic feet:

a 12.43 gal. = 1.662 cu.ft.
b 251 cu.ft. = 1,880 gal.
c 3.31 gal. = 0.443 cu.ft.
d 0.763 cu.ft. = 5.70 gal.

Squaring a number is equally simple as shown in Fig. 4. There the slide has been removed to avoid confusion, since only the *A* and *D* scales are needed. To square any number, set the runner at the number on *D*. Directly above on *A* will be the square. This is illustrated by the following examples:

a.... $1.09^2 = 1.185$
d.... $24.7^2 = 610$
e.... $30^2 = 900$
g.... $0.493^2 = 0.243$
j.... $0.079^2 = 0.00625$

Here, as in all the previous problems, no attention was paid to the decimal point until the figures of the answer had been obtained. Then the point was located by a rough mental computation.

We now come to square root, in which (along with cube root) attention must be paid to the decimal point in the number when setting the runner.

The general process in taking a square root is the reverse of squaring. The number is found on *A* and the root lies directly below it on *D*. The only difficulty lies in deciding on which half of scale *A* to read the number. The square root of 4 is 2 as shown at *c*, but the square root of 40 is not 2 or 20. Moving the runner to *i*, we find $\sqrt{40} = 6.32$. For 400 we come back to *c* and read $\sqrt{400} = 20$. For 4,000 we go again to *i* and read $\sqrt{4{,}000} = 63.2$, and so on. The following rule for square root will always give the right answer:

To extract a square root, shift the point in the number two places at a time to get a number lying between 1 *and* 100. *Find this number on A, on the left if between* 1 *and* 10, *and on the right if between* 10 *and* 100. *Directly below on D read the root as a number between* 1 *and* 10. *Then move the decimal point back half the number of places it was originally shifted.*

This rule is long to state but rapid in application. For example, suppose we want the square root of 25,900. Shifting the point two places at a time, we get 2.59, which lies between 1 and 100. Since it is also between 1 and 10, we read it on the left half of *A* at *b*. Below it on *D* is 1.61, which is the square root of 2.59. When turning 25,900 to 2.59, the point was moved four places *to the left*. Therefore, move the point back *two* places ($\frac{1}{2} \times 4$) *to the right*, giving the actual root, 161.

As another problem suppose it is desired to find the square root of 0.16. Moving the point two places at a time, we find that a shift of *two* places *to the right* gives 16.0. Since this lies between 10 and 100, find it on the right half of *A*. The corresponding square root on *C* is 4.0. Then move the point *one* place ($\frac{1}{2} \times 2$) *to the left*, giving 0.4 as the final answer.

Some slide rules have a special scale on the lower edge for cubes. This is divided into three similar sections (left, center and right) and is read against the *D* scale by a scratch on the edge of the runner in line with the scratch on the glass. To cube a number bring the runner to the number on *D*. Then read the cube where the scratch falls on the edge scale.

For cube root the process is reversed, attention being paid to the decimal points as in square root. The rule is this:

To extract a cube root, first shift the point in the number three places at a time until a number between 1 *and* 1,000 *is obtained. Find this (with the runner) on the edge scale, using the left scale if the number is between* 1 *and* 10, *the center if between* 10 *and* 100 *and the right if between* 100 *and* 1,000. *The root as read will be a number between* 1 *and* 10. *Then move the decimal point back one-third the number of places it was originally shifted.*

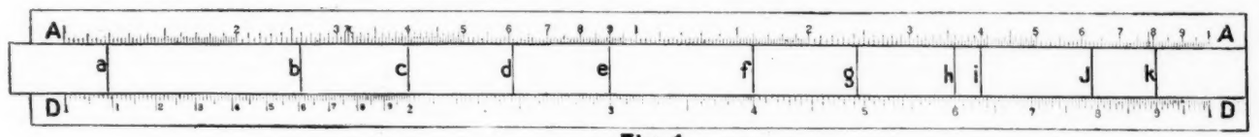


Fig 4

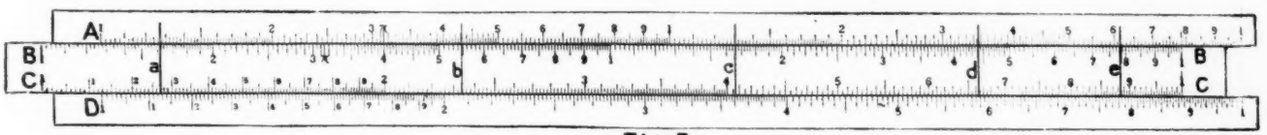


Fig 5

FIG. 4—FINDING SQUARES AND SQUARE ROOTS. FIG. 5—FINDING THE AREA FROM THE DIAMETER

Suppose we want to find the cube root of 23,400,000. Moving the point three places at a time we get 23.4 by a shift of *six* places *to the left*. As this lies between 10 and 100, find it on the *center* edge scale. Opposite on the *D* scale is the root 2.86. Move the point two places ($\frac{1}{3} \times 6$) *to the right*, giving 286 for the final answer.

One special use of the slide rule is of so much importance that it should be explained briefly. It is often desired to get an area from a diameter. The method is to square the diameter and multiply by 0.7854. This can be done in one step if the slide is first moved to the proper position. Set the slide as shown in Fig. 5. Note that the right index of *B* is set on a special mark placed at 0.7854 on *A*. Now if the runner is moved to any diameter on *C*, the area will be directly above on *A*. For example, *a* shows that the area of a 12.7-in. circle is 127 sq.in. and *c* that the area of a 4.06-in. circle = 13.0 sq.in. The decimal point is fixed by noting that the area must be a little less than the square of the diameter.

Further examples may be worked out as follows:

	Diameter	Area
b....	2.34....	4.31
d....	66.4....	3,460
e....	0.884....	0.614

Ash Handling*

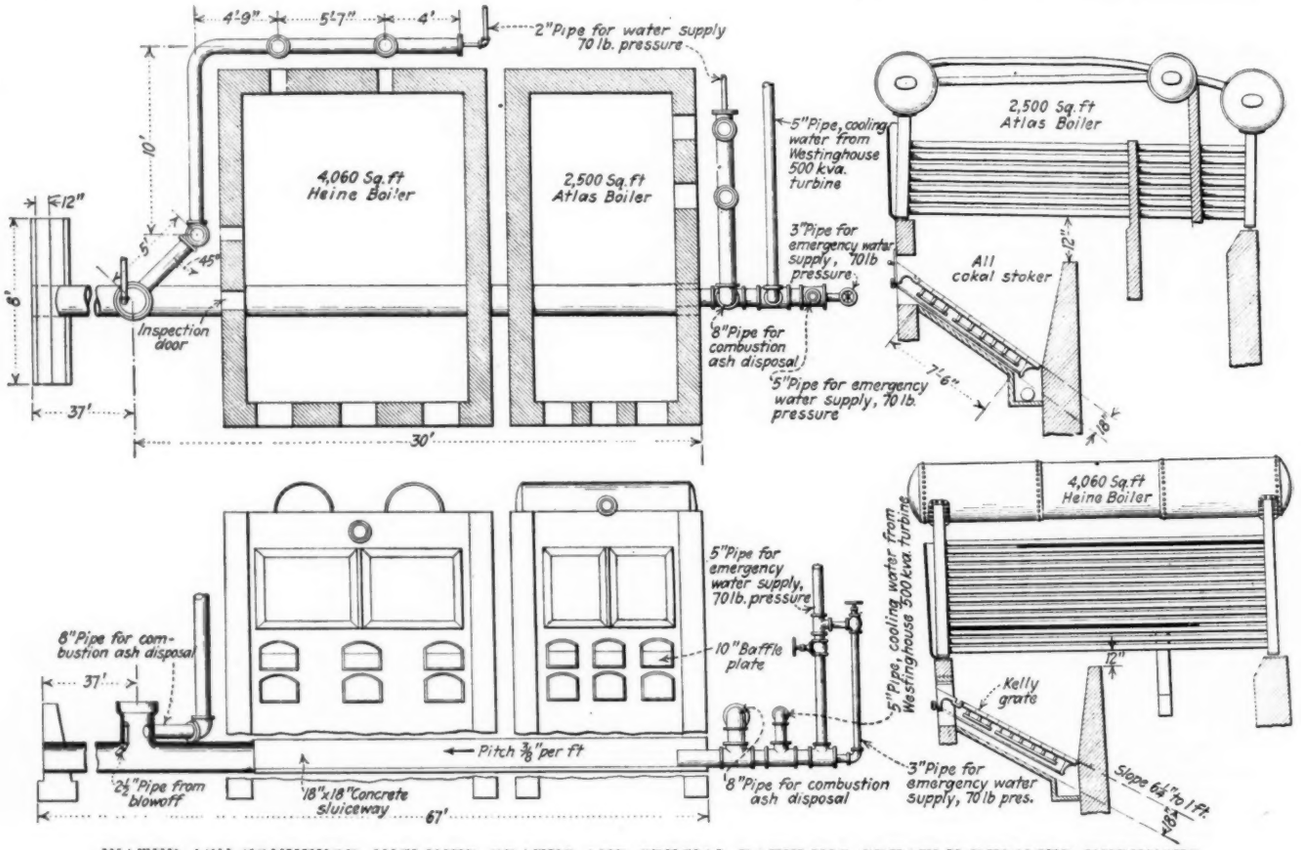
By Rankin Eastin†

Ash handling in power plants at the present day and time is as vitally important as combustion and the handling of coal, when labor, dust and many other objectionable points are considered.

After taking charge of this plant by special request of the Mayor of Tell City, in September, 1920, I devoted all my attention to the boiler room primarily, for the first eight or twelve months, owing to the excessive cost of coal and labor necessary to bring about the necessary results. The boilers were fired on the flat surface grates, and ash handling was one of the principal problems, particularly so after I had the grates dropped on both boilers. It was desired to avoid the expense of tunnels, ashpits and various fly-ash doors around the boiler settings. Sluicing was done by a 2 in. pipe, together with a 5-in. and a 3-in. emergency supply, all at 70 lb. pressure.

The main sluice under the boiler is 18x18-in. concrete, the outlet being installed of 18-in. vitrified sewer pipe. The installation of this system cost only $350 including all material. The labor was the regular plant labor, while the men were paid for extra time, which was figured in the total cost. The system has been in operation about a year, but maintenance has not amounted to anything during that time, with no trouble of any consequence, while there are, of course, times when it requires attention, judgment and forethought on the part of the firemen.

At the discharge of the disposal system there is a platform upon which the ashes are sluiced out. They are placed in piles on either side, for the convenience of the city in using for the streets. Ashes may be disposed of at the



WATER ASH CONVEYOR, INCLINED GRATES AND SPECIAL BAFFLING GREATLY REDUCED EXPENSES

mechanical conveyors. The idea of the water conveyor was suggested by dropping a half brick into an 18-in. sewer under the power plant which carried condenser cooling water. This was moved readily, and it was found that sufficient water would carry a whole brick to the mouth of the sewer, which was over sixty feet away with a fall of 2½ to 3 in. to the foot. It was not possible to obtain this grade for a water-conveying system, but one was installed with a fall of only ⅜ in. per foot. This passed clinkers weighing as much as 15 to 25 lb. successfully by installing a 5-in. emergency pipe from the water system, at 70 lb. pressure. A 3-in. water pipe was also installed for sluicing when only one small turbine unit was in operation, as on Sundays.

The system became so successful that auxiliary means were installed for taking care of fly ash and soot. An 8-in. sewer for this purpose was installed with inlets at the river side, in case the city cannot use the entire amount. This idea may be applied in almost any plant. The catch platform is made of concrete of the porous type, underlaid with ordinary 4-, 6- or 8-in. drain tile, closely honeycombed, leading the sluice water into a reasonable sewer outlet. A centrifugal pump may be installed at a nominal expense, to take care of the sluice water. A conveyor or crane may be used for handling ashes, as desired.

Burning Slack Coal

The plant contains a 4,060-sq.ft. Heine, and a 2,500-sq.ft. Atlas boiler. They originally consumed every 24 hours 10 to 12 tons of the best mine-run coal, which cost $5.50 per ton delivered. It was impossible to burn a cheaper grade of coal in these grates. The grates were then lowered 6¼ in. per ft., and at the same time were given a greater breathing capacity by drilling 1,400 holes ⅝ in. in diameter, in them. This made it possible to burn slack mine coal at a saving of $10 to $12.

After a while an idea came which gave better results. The Kelly grate was then converted into a hand stoker. It

*Abstract of a paper which was presented for discussion at the Dec. 4, 1922, meeting of the American Society of Mechanical Engineers, but has not before been published.

†Mechanical and electrical engineer and superintendent Tell City (Indiana) Water, Light and Power Company.

would seem impossible to keep the coal from rolling continuously down these grates, but this was contradicted by actual experience. An excess of cold air was prevented by carrying a hot cinder bed to a depth of 8 or 10 in., which tended to preheat the air as well, representing an improvement over usual stoker practice.

In hunting for cheap coal, some old slack that had been mined 20 or 30 years ago, amounting to 800 or 1,000 tons, was located at a distance of 7½ miles. The entire amount was purchased for $25. This was transported to the power house by means of a 5-ton motor truck at a cost of $1.50 a ton, delivered, which meant a great saving to the city and the plant.

The National Chamber of Commerce Discusses the Coal Question

One of the sectional meetings of the annual convention of the National Chamber of Commerce at New York was devoted to coal.

J. D. A. Morrow, formerly vice-president of the National Coal Association and now president of the Morrow Callahan Coal Co., of New York, who was to have talked on "Some Problems of Coal Distribution," was prevented by illness from being present.

J. G. Bradley, of the Elk River Coal and Lumber Co., gave a spirited address on "The Effect of Labor on the Cost of Coal." His company operates at Dundon, W. Va., on non-union lines, and his talk was a plea for the freedom of the American wage earner to work at what he pleased, for whom he pleased, and at any wages that were acceptable to him.

Of the entire anthracite production of 100,000,000 tons per annum, only 20,000,000 came into competition with the 450,000,000 of bituminous. They could put bituminous coal into the very towns where anthracite was mined, and the anthracite operators would use the cheaper bituminous coal to run their mines, if it were not for putting the anthracite that it would displace out on the market.

He divided the labor cost of coal mining into the direct and indirect and put the direct cost at 60 per cent, or roughly $2 a ton, or for the 500,000,000 tons of bituminous coal mined, a billion dollars a year. Two per cent more might be added for the labor content of the supplies that go into the mines. But the direct labor cost is not the most important cost. They, non-union operators, have men who produce more than 10 tons of coal a day. The average for the country is 650 tons per year per man, in the non-union field 1,500 tons.

But it is of no use to produce coal if one has no cars to put it in. The effect of car shortage on the cost of coal is as follows:

Car Supply Off, Per Cent	Additional Cost, Per Cent
20	12
30	19
60	54

The market price of coal has been made since 1917 by the problems of transportation. Garfield muddled along with priority orders, putting coal on the sidings until he found that coal was necessary to produce the goods to which he was giving priority. Then came the coal strike, followed by the railroad strike. Then came Storrow from New England —what he wanted was not more coal for New England but to break the price. He was shown that New England would be provided for so far as quantity was concerned and sent back home.

Any man would take $20 a ton for his old tin if he could get it, and they, the operators, took it for theirs and had been cussed for it ever since. They were "the unwilling victims of circumstances."

Then came another coal strike and then the switchmen's strike, and the coal-using public had got to pay the price of them. The mine strike of 1919 cost $400,000,000; that of 1922, $1,190,000,000.

Cheap power is the absolute foundation of industrial supremacy. It cost 73 cents to mine a ton of coal in 1914 and $2.45 in 1921. Common labor is getting $7.50 a day. The average cost of mining coal with non-union men is 72 cents a ton less than the country's average. Imagine that saving of 72 cents a ton applied to the 500,000,000 tons produced.

He arraigned the legislators who refused a subsidy to the enterprise upon which the country depends for the carrying of its ocean freights and the extension of its commerce, but subsidized the labor monopoly of the miners' unions which loaded upon the price of coal and thus assessed upon the consumer the great sums necessary for their support and aggressive operations.

George H. Cushing, publisher of the *Cushing Survey*, Washington, D. C., spoke on "Economic vs. Legislative Solution of the Coal Problem." He was not quite willing to scrap our legislatures and rely entirely upon the integrity of our business interests.

One of the principal difficulties of the coal situation is that the mines work a maximum of 245 out of the available 308 working days of the year.

Merchandising is responsible for more than 50 per cent of the trouble. If it were not for the high price of anthracite, which hits the small ultimate consumer directly, there would not be half so much complaint of extortionate prices.

The public-utility commissions fix the price at which utilities can sell their services on an existing fuel price, and then the price of coal goes up and cuts out their profit. A bound consumer and a free producer are incongruous.

Proposed Legislative Remedies

The stabilization of the coal industry was a much talked of but ill-defined proposition. In some way the supply of coal was to be made to flow in a measured stream from producer to consumer and all the seasonal irregularities smoothed out. We have 10,000 coal mines and 5,000 of them would have to be wiped out. We have the equivalent of a seam of coal 5½ ft. in thickness covering 775,000 square miles of territory; under actual development only 10,000 to 15,000 square miles. We would have to scrap the titles to all the rest, and the men will be left with only the joy of work and the fun of spending their money.

Another proposition is community storage. It would cost 50 to 60 cents a ton for extra handling in addition to degradation and insurance, and such stored coal could not be sold in competition with that freshly mined.

The third proposition is consolidation of the mines by districts, an approved combination in the interest of efficiency. This would mean the scrapping of the inefficient operations, and the coal mined by those that were left would have to carry their capital charges.

The fourth proposition is the nationalization of the coal mines, which would be the opening wedge for a complete overturn of our social and industrial system, require a new declaration of principles with regard to title and commit the government to a betrayal of the consumer by guaranteeing the returns of capital and the wages of labor.

Mr. Cushing then suggested as remedial measures:

1. That the railroads should be put into a position to serve the coal industry fully and promptly as the people may demand.

2. The people of the United States should not permit any more nation-wide strikes, and for their avoidance the expiration of wage contracts should be staggered.

2. Every state which has a statute on its books which provides that nobody shall work in that state unless he has a certificate of competency, should strike it out tomorrow.

4. The public opinion of the United States should encourage every non-union district to remain non-union to set up a buffer between the consumer and the demands of the union.

5. In future the railways of the United States should not be obliged to give service to a new mine or a new producer of coal until he has given at least nine months' notice to the railways that he wants additional facilities to carry his coal to market.

6. The public opinion of the United States should support the operator if confronted by the refusal of the miner to use cost-cutting and labor-saving machinery and should declare the contract under which that thing is done to be void and cancelled.

News in the Field of Power

Steam Pressure of 1,200 lb. Planned for Weymouth

In view of the progress made in the design of the new Weymouth Power Station of the Edison Electric Illuminating Co. of Boston, the following announcement has been issued, covering its more important features:

The station site is about eight miles distant from the company's present L Street Station, the new plant being on Weymouth Fore River. Contract has been placed with the General Electric Co. for two main generating units to operate at 350-lb. pressure, and negotiations are under way with the same company for one high-pressure unit to operate at 1,200 lb. pressure, exhausting through a resuperheater into the steam mains supplying the main generating units. The steam temperature for both the high-pressure and main generating units will be 700 deg. F.

The steam ends of each of the two main generating units will have a maximum rating of 32,000 kw. and will be direct-connected to a generator of 30,000 kw. capacity and an auxiliary generator of 2,000 kw. capacity for station auxiliary service. The high-pressure unit will generate about 2,000 kw. It is planned that three of these units exhausting at 375 lb. will furnish enough steam for one main generating unit. The four boilers will be made by the Babcock & Wilcox Co. One will be designed to operate at 1,200 lb. pressure and three at 375 lb. pressure. The resuperheater will be installed in the high-pressure boiler setting. High-pressure-type economizers will be installed with both the 375-lb. and the 1,200 lb. boilers.

The adoption of 1,200 lb. pressure for the initial stage requires the working out of many new problems in the design of the station. The work is under the supervision of I. E. Moultrop, of The Edison Electric Illuminating Co. of Boston, and Stone & Webster, Inc., have been engaged to design and build the plant.

Buy Your Coal Now!

Most of the governmental bodies interested in the problem of coal are urging the domestic and power-plant consumer to lay in his winter's supply of coal. The present anthracite miners' and mine operators' agreement expires August 31; the bituminous miners' and mine operators' agreement expires in April, 1924, and according to the United States Coal Commission "The responsibility for stabilizing supply and prices rests in no small degree on the consumer because it is the consumer who controls the demand for coal."

The production of anthracite, according to the Geological Survey of April 28, shows that the cumulative output during the present calendar year from Jan. 1 to April 28 was 31,602,000 net tons. Bituminous output has shown a slight decline since April 11, but up to that time it was averaging 10,500,000 tons per week.

The Ruhr situation in regard to production of coal does not appear very promising. Our exports to countries formerly supplied by the Ruhr and Saar districts are rising tremendously, especially in the demand for coke. When France, Italy, Belgium and the Netherlands are increasing their demands, the result will be a rise in price and a scarcity of fuel. With or without a controversy between the miners and the mine operators in the anthracite field, there is going to be a strong demand for coal next fall and winter, and the anthracite consumer is going to feel it if he does not attend to getting in his supply during the slack season for miners and coal cars.

The anthracite operators have committed themselves thoroughly to the policy of selling coal to any group of ultimate consumers willing to buy as much as full carload units, and to ship to any point where side-track facilities are available. The way is open for any householder, therefore, who is dissatisfied with his dealer's price, to club together with three or four of his neighbors and purchase a carload of anthracite direct.

Gas Engineering Courses for Johns Hopkins

The School of Engineering, Johns Hopkins University, is announcing new courses in Gas Engineering. This has been made possible by a donation of $6,000 per year for a period of five years, by the various gas industries and public-service corporations in sixteen Southern states, the subscription being made through the Southern Gas Association. Up to this time no engineering school has offered a course in gas engineering. The Johns Hopkins University was selected as the school in which the new course should be located, largely because of the gas byproduct or research laboratory located there, also a donation of a few of the gas industries, its courses in allied fields of mechanical and chemical engineering and its convenient location with reference to the Southern states.

The School of Engineering is also announcing a number of new courses through a closer co-ordination between the school and the College of Arts and Sciences, as it is now generally recognized that engineers, in addition to their professional training, must have a more liberal education in literature, history, modern languages, economics, business and other sciences.

Federal Power Commission and N. Y. Officials Confer

The appearance of the attorney general and state engineer of New York, along with other interested New York State officials, before the Federal Power Commission, gave further color to the belief that the state administration is attempting to ease out gracefully from under its bill of complaint attacking the constitutionality of the Water Power Act. This is not a new attitude for New York to assume.

The conference with the Federal Power Commission, which was executive, is understood to have resulted in making clear to the representatives of the New York administration, that the Federal Power Commission does not interpret the Water Power Act as strictly as is alleged in the bill of complaint. It is understood that the New York delegation admitted that the bill was in error to that extent. It also was admitted, it is said, that many limitations on the Commission had been entirely overlooked in the bill, which led to a wrong conclusion as to the scope of the Commission's power.

There is every reason to believe that the conference has resulted in a material clearing of the atmosphere. Practically the only point of difference which was not eliminated at the conference was that as to the scope of the Federal authority over water power.

New York Interborough to Increase Boiler Plant

The Interborough Rapid Transit Co., New York City, has plans under way for extensions to the steam-generating equipment at its Fifty-ninth Street station. Improvements will include four 12,000-sq.ft. Babcock & Wilcox boilers, four Taylor underfeed stokers and four Sturtevant fans for forced and induced draft service.

The boilers, two of which will be installed this summer and two early in 1924, will be designed for 350 lb. pressure, but will operate for the present at 220 lb. gage and an approximate total temperature of 600 deg. F. One boiler will be fitted with a Foster radiant-heat superheater.

The stokers will be 7-retort, 37 tuyeres in length, being the longest Taylor stokers yet built. The furnaces will be approximately 12 ft. wide by 17 ft. deep. This special design was necessitated by the existing steel structure of the plant. The stokers will be driven by variable-speed motors.

One forced- and one induced-draft fan will be installed for each two boilers and will be motor driven. Economizers

will not be installed at the present time but provision will be made for them should operating conditions warrant their installation.

To take care of the change in heat balance brought about by the installation of motor-driven auxiliaries instead of steam as in the present equipment, steam will be bled from a low-pressure stage of the main turbine units.

New Development On Farmington River

The Farmington River Hydro-Electric Co. has been organized under laws of Delaware for the purpose of building three dams on the Farmington River, in the towns of Otis and Sandisfield, in the western part of Massachusetts. A total of 1,535,000,000 cu.ft. of water will be impounded. The power house will be at New Boston in Sandisfield, and the dams will all be to the north. The first dam will be 40 ft. high by 450 ft. long, and will flood 600 acres. The second will be 20 ft. high and 200 ft. long, while the third will be 25 ft. high and 400 ft. long. The power plant will contain two 2,000-hp. turbines. Later, it is planned to erected a dam to the south of New Boston, which will be 20 ft. high by 250 ft. long, and a powerplant containing two 1,800-hp. turbines.

Contention Over Sites on New River

Owing to the fact that the market for electric power in southern West Virginia and northeastern Virginia is growing at a compounded rate of more than 20 per cent per annum, a determined fight is in prospect for the power site near Hinton, W. Va., on New River. The contending applicants are the Virginian Power Co., which is a going concern with headquarters at Charleston, W. Va., where it is operating a 60,000-hp. steam plant, and the Appalachian Power Co., whose activities center at Roanoke, Va. The latter company owns most of the flowage lands required and is now contemplating pushing a development that calls for the construction of six plants on New River. The lower two plants are in direct conflict with the application of the Virginian Power Co.

The Engineer in Public Affairs

That the meeting of the Metropolitan Section, A. S. M. E., May 8, was organized by the Federated American Engineering Societies, the Federation being the outgrowth and embodiment of those things which engineers feel can better be done unitedly than separately, was brought out by Gano Dunn, president of the J. G. White Engineering Corporation, who presided.

Admiral John Keeler Robison, chief engineer of the United States Navy, spoke of the Navy as an example of engineering service where devotion to duty and self-sacrifice have resulted in such a wonderful fleet of ships. He dwelt at length on the value of the Navy in maintaining the peace of North and South America as well as preventing in this country the deplorable conditions that followed the wars in Europe.

Turning to the technical side of the Navy, he described how ships that averaged a cruising radius of 5,600 miles last year will now average 9,000. The expenses for the power per knot have been decreased about one-third while under way, and there has been a greater decrease for the unit of time spent in port.

The cost of engineering repairs and supplies has been reduced with an equally impressive ratio. Self maintenance of the fleet has placed more material on ships at approximately one-half of the cost two years ago. These improvements have been the result of the necessity for economy during the last two years and have been so well carried out that in all cases the ships have been amply supplied with fuel and other necessities. The cost of lubricating oil was reduced about one-third by the use of centrifugal oil-cleaning devices aboard ship. A large saving in fuel was effected by using exhaust instead of live steam for the evaporation of salt water.

Col. F. B. Jewett, president of the American Institute of Electrical Engineers spoke in place of Senator Thomas Sterling, of South Dakota, who could not be present. He dwelt especially on the course which the engineer must take when entering wider fields or in taking up new public duties.

Dean Cooley Addresses Chicago Section A.S.M.E.

The annual dinner of the Chicago Section of the American Society of Mechanical Engineers, held May 15, was a decided success. As is customary at the last meeting of the season, the ladies were invited and a special program was arranged. A number of musical selections and some community singing helped to break down the reserve and open wide the channels of sociability.

The following officers were elected: Chairman, E. P. Rich; vice-chairman, J. D. Cunningham; secretary-treasurer, F. B. Orr; executive committee, G. E. Pfisterer and T. S. MacEwan.

Dean Mortimer E. Cooley, of the University of Michigan, was the speaker, and his subject was "The Engineer," what he had done to create and advance civilization and what he should do to help preserve it. A number of references served to show that the engineer was responsible for most of the material things that had made the civilization of today. The country in general was undeveloped and the great wheat fields were useless until the engineer built the railroads. The improvement in communication gave us one language instead of a great number of widely varying dialects. Yet with it all, how many think of the engineer in this way? This is partly due to the modesty of the engineer and partly to the fact that he does not render a personal service such as the doctor, the lawyer or the minister. All his work is indirect. He does it for someone else.

On the other hand, while the engineer has done all these things for the creation of civilization, he has done nothing to help preserve the things he has created. The average engineer is narrow, and while well trained in his particular specialty, he knows little else. His education is partly to blame. Forty years ago he was better qualified than today. At that time all engineering textbooks could be carried under one arm and with the time and the number of hours of credit the same, it was necessary to study other subjects such as geology, astronomy, history, and philosophy, all contributing to the culture of the student. Today there are engineering books by the carload and difficulty is found in making a selection. The engineer is trained well in his own particular specialty, but the rest of his education is neglected even in the preparatory schools. The industries are awake to this situation and are demanding changes in the curriculum.

To take his proper place in the world's work, the engineer must have a broader education and he must realize that he has something to do over the mere work by which he earns a living.

New Publications

Ventilation: Report of the New York State Commission on Ventilation. Published by E. P. Dutton & Co., 681 Fifth Ave., New York City. Cloth; 7¼x10¼ in.; 620 pages, 134 figures, 219 tables and an appendix of 47 tables. Price, $15.

Extensive experiments were made and much research work was done under the direction of the New York State Commission on Ventilation, appointed in 1913 and supported by the Milbank Memorial Fund, of which this book of twenty-seven chapters, each explaining definitely what was attempted and the conclusion reached, is the result. Chapters deal with the much-discussed question of window versus fan ventilation. The following statement apparently indicates the superiority of window ventilation: "It seems quite possible that the strong, steady currents of air at a uniform temperature, characteristic of fan ventilation may be actually less desirable than a less intense but more fluctuating air flow of slightly varying temperature."

Among the principal conclusions are the statements: The most harmful influence in the history of the art of ventilation has been the tendency to adopt certain standardized procedures and apply them without special study to individual cases; window ventilation method shows great promise and perhaps would be found more frequently useful than any other procedure for average classrooms; avoidance of over-

heating is the primary essential in all systems of ventilation, air change, direction of flow and all other factors being secondary; the most important article of ventilation equipment is the thermometer; however complex an apparatus may be installed for air conditioning, a constant and intelligent vigilence in regard to operation and overheating is the price of comfort.

Mechanical Testing—Vol. II. Testing of Prime Movers, Machines, Structures and Engineering Apparatus. By R. G. Batson and J. H. Hyde (both of the National Physical Laboratory, Teddington, England). Published by E. P. Dutton & Co., New York City. Cloth; 5½x8½ in.; 446 pages; 313 illustrations. Price of Vol. II, $10.

The first volume, "Testing of Materials of Construction," was reviewed in the Aug. 1, 1922 issue. This second volume, like the first, covers its field in a thorough manner. Considerably more than half of it is of direct interest to engineers concerned with the testing of power equipment. The discussion of dynamometers, which occupies the first 127 pages and is accompanied by nearly a hundred illustrations, is particularly comprehensive. Absorption, transmission and traction dynamometers are treated separately and in detail. Other sections containing information applicable to the power field treat of the testing of springs, lubricants, friction of bearings, static and dynamic balance, vibration, pressure measurements, etc. The portions dealing with the testing of concrete slabs, beams, columns, etc., the measurement of movements and stresses, tests on cutting tools and aircraft models, are directed more to other branches of the engineering profession. For practical testing work this book contains a great deal of valuable material not to be found in the ordinary textbooks and treatises on the subject.

The Federal Power Commission; Its History, Activities and Organization. By Milton Conover. Published by The Johns Hopkins Press, Baltimore, Md., 1923. Cloth, 6x9 in.; 126 pages. Price, $1.

To lay the foundation for a comprehensive study of the organization and operations of the national government, the Institute for Government Research has undertaken the preparation of a series of service monographs, covering the various boards, services, commissions and bureaus, of the government, of which this monograph on the Federal Power Commission is one. These are intended to be informative to the shifting personnel of the government departments; for purposes of cooperating the various agencies of the government in their activities; for congressmen; for the public.

The Federal Power Commission monograph takes up the history of water power in the colonies, states and the nation, giving the details of interesting disputes like the "War of Woodbury Dam," which agitated provincial and state governments for seventy years, in the eighteenth century, up to the present contentions over the Colorado, the St. Lawrence and the Niagara Rivers.

Gradual development of federal water-power administration within the executive departments is described: The War Department controlled the use of navigable rivers; the Department of the Interior, through the General Land Office and the Geological Survey, cared for the granting of permits for reservoirs and canal privileges; the Department of Agriculture, where the relation of forest cover to the flow of streams and study of watersheds were considered.

The development of the fundamental principles leading to the establishment of the present Federal Power Commission in 1920 were laid during the presidency of Theodore Roosevelt, when the idea of the co-ordination of existing agencies for the protection against monopoly and fees and time limits for power privileges were voiced by him in vetoes of various dam projects.

The activities, an outline of the organization, the publications including laws and acts, and various sets of statistics are contained in this small but comprehensive and timely volume.

E M F Electrical Year Book. Edited by F. H. Bernhard. Published by Electrical Trade Publishing Co., Chicago, Ill., 1923. Cloth; 9x12 in.; 1,230 pages; illustrated. Price, $10.

This is the second edition of this book, which is a combined dictionary, encyclopedia and trade directory covering the electrical industry. All topics are alphabetically arranged so as to be convenient for reference. Nearly half of the 14,000 topics in the first edition have been rewritten or revised and several thousand new topics added. The dictionary feature includes definitions of electrical terms of both scientific and practical interest. In the encyclopedia part are given facts and figures on the electrical industry as a whole and on each of its branches. There are also biographies of electrical men and lists of electrical associations, colleges, libraries and periodicals. The trade directory includes some 3,150 classifications of electrical and related products, each with a list of its manufacturers; there are also separate entries for each of the manufacturers under his own name and under each of his trade names. There are sections dealing with hydro-electric and steam-electric power plants.

The entire text is arranged in one continuous alphabetical section, and any information sought will be found by using the book as one would use an encyclopedia, dictionary or telephone directory. To those who require current information about the electrical industry as a whole and each of its branches, its service or products and their producers, its terminology, and other frequently sought facts and data, this book contains much to recommend it.

Metals and their Alloys. By Charles Vickers. Published by Henry Carey Baird & Co., Inc., 2 West 45th Street, New York City Cloth; 779 pages. Price, $7.50.

When sizing up a technical volume, one instinctively wonders what the author has accomplished in the field represented by his book. An author of wide technical experience, and also the ability to express his thoughts on paper, can be trusted to produce material worth reading. Mr. Vickers is a specialist in melting, alloys, casting metals, and is engaged also as technical adviser to manufacturers of non-ferrous castings. As metallurgical editor of the *Brass World* and non-ferrous editor of *Foundry*, his editorial experience in addition, well fitted him to produce desirable volumes. Various elements and alloys are taken up, first from a historical point of view and then from that of the metallurgist or manufacturer where the commercial preparation is described, together with copious tables of physical and chemical properties. This book is not only instructive, useful and practical considerably beyond the average, but it is most interesting in itself as reading matter. In dealing with alloys for making bells, the author describes many famous bells, including the Great Bell of Moscow, which weighs 220 tons and is supposed to be one of the largest bronze castings in the world. This was begun 1732 and completed about 100 years later. With such side lights on the technical arts, the actual instruction is made interesting.

Steam Turbine Principles and Practice. By Terrell Croft. Published by McGraw-Hill Co., Inc., New York City. Cloth, 5½x8½ in.; 347 pages. Price, $3.

This book was written for those who operate steam turbines or manage properties containing such machinery. The subject matter has been designed to supply the man who operates with the necessary facts to do so successfully and economically, and those who purchase steam turbines, with the information that would lead to making a wise choice. The fundamental principles are described and connections to some of the basic formulas illustrated. Various parts which make up commercial steam turbines are profusely illustrated and described, together with instructions for their operation in connection with steam turbines. Each chapter is followed by a list of questions, which will enable a man to check his understanding of the contents. This material is contained in 238 pages, including 275 figures. Operation and maintenance of turbines in general is treated in one chapter; steam-turbine testing in another; the effect of steam pressure and superheat in varying the water rate, as well as the economics and principles of selecting turbines in the last two chapters or divisions. A voluminous index is attached. The book contains much desired up-to-date information for the operating men and executives, covering steam turbines in a comprehensive manner.

Personal Mention

E. W. Rockafellow, has resigned from the Western Electric Co., to accept the vice-presidency of the National Pole Co., Escanaba, Mich., and will be at 220 Broadway, New York City.

F. A. Combe, consulting, combustion and steam engineer has recently been selected as a member of the Executive Committee of the Montreal Branch Engineering Institute of Canada.

Allen B. Coffman has resigned as sales engineer for Crouse Hinds Co., to become manager of the Philadelphia district for the Reliance Electric & Engineering Co., at Cleveland, Ohio.

Dr. H. C. Dickinson, formerly head of the Automotive Power Plant Section of the Bureau of Standards, has returned to that Bureau as chief of the Heat Division, assuming his duties May 2.

James D. Andrew, formerly president of the American Balsa Co., has accepted the position of vice-president and district manager of Stevens & Wood, Inc., with headquarters at Youngstown, Ohio.

George Baily, supervisor of distributing agents of the Westinghouse Electric & Manufacturing Co., has been elected president of the Varney Electrical Supply Co., of Indianapolis, Ind.

A. L. Schieber, formerly manager of the generator section of the power department of the Westinghouse Electric & Manufacturing Co., has been appointed export representative of that department.

Rawson Collier, until recently general sales manager of the Central Hudson Gas & Electric Co., has joined the organization of Dwight P. Robinson & Co., Inc., 125 East 46th St., New York City.

Harold H. Perry, manager's assistant, Industrial Works, Bay City, Mich., has sailed for England. He intends to make an extensive study of locomotive and wrecking cranes used in that country.

C. G. Brown, of Shanghai, Pekin and numerous other places in China, gave *Power* an enjoyable call recently. He is returning to that country with contracts to represent a number of leading American manufacturers of power-plant apparatus.

Obituary

William Shreeve Doran, president of the Alberger Pump and Condenser Co., New York City, died on Saturday, May 12.

Mr. Doran was born in Philadelphia on May 15, 1864, and received his early business training with the Southwark Foundry & Machine Co. and the United Gas Improvement Co. of that city. In 1887 he entered the employ of Henry R. Worthington, filling various positions in the New York City office and abroad, until in 1900 he became affiliated with the London office of the British Westinghouse Co. After leaving the Westinghouse company, he spent about three years with the Allis-Chalmers Co., of Milwaukee in charge of the power department. Later, in 1920, he was elected president of Charles Cory & Son, Inc., manufacturers of marine specialties, and in 1921 he became president of the United Marine Contracting Co.

Mr. Doran was vice-president of the Engineers' Club of New York City, a member of the American Society of Naval Engineers, the Society of Naval Architects and Marine Engineers, the Railroad Club and various other organizations.

Henry Woodland, secretary and treasurer of the Allis-Chalmers Manufacturing Co., of Milwaukee, died Monday, May 14, after an illness of less than twelve hours. The immediate cause of his death was a cerebral hemorrhage which occurred shortly after dinner on Sunday.

HENRY WOODLAND

Mr. Woodland's connection with the company dates back to 1901, when the Gates Iron Works, of Chicago, was consolidated with the Allis-Chalmers Company. Mr. Woodland had been treasurer of the Gates Iron Works and in the consolidation became assistant treasurer of the Allis-Chalmers Company, going to Milwaukee when the general offices of the company were transferred to that city. Shortly after the transfer he was made treasurer of the company and in 1916 was elected secretary and treasurer. He was also vice-president and a director of the Hanna Engineering Company, of Chicago.

Born in Utica, N. Y., and educated in the public schools of that city, Mr. Woodland as a young man came to Chicago and became associated with the New York Air Brake Company and later with the Gates Company. He was married in 1888 and is survived by his widow and a son, Ralph, now a resident of Evanston, Ill.

Mr. Woodland was active in public life. He was a member of the Milwaukee Club, the Athletic Club, the Chicago Athletic Club and the Mid-day Club of Chicago.

Society Affairs

The **Ninth National Exposition of Chemical Industries** is to be held in the Grand Central Palace, New York City, during the week of September 17th.

The **Philadelphia Section** of the A.S.M.E. will hold its annual dinner at the Hotel Adelphia on May 22. Prof. Vide Bouteille will speak on "The Generation and Utilization of Power in the Future."

The A.S.M.E.—Fuel Division—Meetings and Papers Committee has a new chairman, William S. Gould. The chairmanship was made vacant through the resignation of David Moffat Myers. C. E. Lesher, editor of *Coal Age* is a member of this committee.

The **Boston Section** of the A.S.M.E. is to have a buffet supper and business meeting at Chipman Hall, Tremont Temple on May 25, followed by an illustrated lecture on the "Caribou Hydro-Electric Development for the Great Western Power Co., Feather River, Calif."

The **New England Association of Commercial Engineers** are going to hold a Power Show in connection with the International Textile Exposition, from Oct. 29 to Nov. 3, at the Mechanics Building, Boston, Mass. James F. Morgan, 53 Devonshire St., Boston, is to be in charge of arrangements.

The **Hartford Engineers Club,** of Hartford, Conn., announces that Hiram Percy Maxim, a local inventor, was chosen president of the newly formed club. Other officers elected were: F. P. Gilligan, first vice-president; Edward W. Bush, second vice-president; K. B. Warner, secretary; Henry R. Buck, treasurer.

The **National Electric Light Association** will hear various reports during its convention, which will be held in New York City at the Hotel Commodore, June 4-8. The Prime Movers Committee, Hydraulic Power Committee, Electrical Apparatus Committee, Overhead Systems Committee, Underground Systems Committee, and the Motor Rules and Service Voltages Section of the Electrical Apparatus Committee will give reports or abstracts of reports.

The **National District Heating Association** will hold its annual convention at the Breakers Hotel, Cedar Point, Ohio, June 20-23. Among the subjects on the program will be the following: Report of Station Operating Committee, R. D. DeWolf, chairman; an address by C. F. Hirshfeld, of the Detroit Edison Co.; Paper—"Powdered Fuel and Symposium on its Results"; Report of Heating Research Committee, H. T. Luscomb, chairman; Address — "Public Relations as a factor in Public Regulation," by Grover C. Maxwell, Columbus, Ohio; Report of Hot Water Committee, E. H. Enander, chairman; Report of Operating Statistic Committee, F. B. Orr, chairman.

The **Indiana State Association of the N.A.S.E.** are to hold their 19th annual convention at Purdue University, Lafayette, Ind., on May 28-29. Among the papers given will be the following: "The relation of the N.A.S.E. to the Central Station Industry," by Morse Dellplain, of the Northern Indiana Gas & Electric Co., Hammond, Ind.; "Education of the Power Plant Employee," by Fred R. Low, editor of *Power;* "Powdered Fuel," by John Anderson, Milwaukee Electric Railway & Light Co.; "Boilers," by a representative of the Heine Boiler Co., St. Louis; "Steam Turbines," by C. C. Douglas, General Electric Co., Chicago; "Power Plant Instruments," by J. W. Hays, consulting engineer, Michigan City, Ind.; "Why Steel Warps," by J. W. Keller, Purdue University; "Lubrication," by Prof. H. C. Peffer, School of Chemistry, Purdue University.

Business Notes

The **Link-Belt Co.** has moved its Pittsburgh, Pa., office from 1501 Park Building to 335 Fifth Ave.

The Carborundum Co., Niagara Falls, N. Y., announces the appointment of Harry Collinson as district sales manager in charge of its Milwaukee office.

Stovel & Brinkerhoff, Engineers and Constructors, announce the addition of H. M. Van Gelder as a partner, and a change of name to Stovel, Brinkerhoff & Van Gelder, with offices at 136 Liberty St., New York City.

Jos. W. Hays is completing the organization of a corps of consulting combustion engineers that are to be known as Jos. W. Hays and Associates, with headquarters in Michigan City, Ind.

The Conveyors Corporation of America, 326 West Madison St., Chicago, Ill. announces the appointment of the Pittsburgh Products Co., Oliver Bldg., Pittsburgh, Pa., as the district representative of its company for western Pennsylvania and northwestern West Virginia.

The **Heine Boiler Co.**, Saint Louis, Mo., announces a change in the organization of its New York City office at 11 Broadway, made necessary by the resignation of Paul H. Bangs and his son Harold A. Bangs. George F. Murphy, formerly connected with the Pittsburgh office, assisted by J. L. Daly and G. A. Knowles, will be in charge.

The Johns-Pratt Co., Hartford, Conn., announces that arrangements have recently been made with the Curtin Mill Supply Co., Houston; Globe Supply & Machinery Co., New Orleans; Hide, Leather & Belting Co., Indianapolis; Hardy & Dischinger, Toledo; Rathbun Co., El Paso; The Miller Supply Co., Huntington; Walworth-Ohio Co., Cleveland, and the Wayne Belting & Supply Co., Fort Wayne, as distributors of its packing specialities and pump valves.

Coming Conventions

American Boiler Manufacturers' Association; H. N. Covell, 191 Dikeman St., Brooklyn, N. Y. Thirty-fifth Annual Convention at Hot Springs, Va., June 4-6.

American Order of Steam Engineers; W. J. Brice, 2126 S. 57th St., Philadelphia, Pa. 37th Annual Convention at Reading, Pa. (instead of Philadelphia, as formerly announced), June 4-8.

American Society for Testing Materials; C. L. Warwick, 1315 Spruce St., Philadelphia, Penn. Annual meeting at Atlantic City, N. J., June 25-30.

American Society of Mechanical Engineers, 29 W. 39th St., New York City. Spring meeting at Montreal, Canada, May 28-31.

Association of Iron & Steel Electrical Engineers; J. F. Kelly, 1007 Empire Bldg., Pittsburgh, Pa. Iron and Steel Exposition at Buffalo, N. Y., Sept. 24-28.

Canadian Association of Stationary Engineers; Gordon C. Keith, 51, Wellington St. West, Toronto, Canada. 34th Annual Convention at Toronto, Canada, June 25-28.

Electric Power Club; S. N. Clarkson, Kirby Bldg., Cleveland, Ohio. Annual meeting at Hot Springs, Va., June 11-14.

International Railway Fuel Association; J. G. Crawford, 702 East 51st St., Chicago. Annual meeting at Cleveland, Ohio, May 21-24.

National Association of Practical Refrigerating Engineers; Ed. H. Fox, 914-25 East Jackson Blvd., Chicago. Fourteenth Annual Convention at Memphis, Dec. 12-16.

National Association of Stationary Engineers; Fred W. Raven, 417 South Dearborn St., Chicago, Ill. Annual convention and exhibition at Buffalo, N. Y., Sept. 10-15. Annual conventions and exhibitions of the State Associations scheduled as follows: **Indiana,** at La Fayette, Ind., May 28-29; T. J. Kelly, 2704 South St., La Fayette, Ind. **New Jersey,** at Trenton, N. J., June 1-3; Samuel Clark, 67 Columbia St., Jersey City, N. J. **Illinois,** at Springfield, Ill., June 6-9; F. W. Raven, 417 South Dearborn St., Chicago. **New England States Association,** at Manchester, N. H., Manchester hotel, July 12-14; Freeman L. Tyler, 32 Briggs St., Taunton, Mass. **Iowa,** at Mason City, Iowa, June 11-14; Abner Davis, Room 16, Waterhouse Block, Cedar Rapids, Iowa. **Ohio,** at Dayton, June 21-23; J. H. Weaver, 22 N. Gift St., Columbus, Ohio. **Pennsylvania,** at Buffalo, Sept. 9-10; J. N. Calvert, Crafton Sta., Pittsburgh, Pa. **New York,** at Buffalo, Sept. 9-10; W. T. Meinzer, Third St., near Warburton, Bayside, L. I., N. Y. **Minnesota,** at Duluth, Aug. 8-10; C. A. Nelson, 800 22d Ave. N. E., Minneapolis. **Connecticut,** at Waterbury, June 29-30; L. Van Der Eyk, 251 Wood St., Waterbury.

National District Heating Association, D. L. Gaskill, Greenville, Ohio. Annual convention at Cedar Point, Ohio, June 20-23.

National Electric Light Association; M. H. Aylesworth, 29 West 39th St., New York City. Annual meeting at New York City, June 4-8.

Ohio Electric Light Association, D. L. Gaskill, Greenville, Ohio. Annual convention at Cedar Point, Ohio, July 10-13.

Smoke Prevention Association; Frank Chambers, 111 N. Dearborn St., Chicago, Ill. Convention at Minneapolis, Minn., June 19-22.

Society for the Promotion of Engineering Education; F. L. Bishop, University of Pittsburgh, Pittsburgh, Pa. Annual meeting at Cornell University, Ithaca, N. Y., June 20-23.

Stoker Manufacturers' Association; J. G. Worker, Eau Claire, Wis. Annual convention at Lake Placid Club, Essex Co., N. Y., May 29-31.

Universal Craftsman Council of Engineers; John F. Amos, P. O. Box 299, Rochester, N. Y. Convention at Rochester, N. Y., Aug. 7-11.

The **Furnace Engineering Co.**, 5 Beekman St., New York City, has recently taken up the manufacture and sale of pulverizers. This line of machinery is designed principally for the production of pulverized fuel, but may be applied to other materials. Dr. Paul M. Hirsh, who has specialized in the design and operation of fuel pulverizers for many years, is associated with the company in charge of this branch.

Trade Catalogs

Specialties—Nason Manufacturing Co., 71 Fulton St., New York City. Bulletin No. 24 describes and illustrates the steam, hydraulic, gas, engineering and plumbing supply specialties of this house.

Boilers, Water Tube—Union Iron Works, Erie, Pa. Catalog explaining the fundamental design and operation of watertube boilers and the construction and operation of the Union Iron Works boilers especially. This handsome catalog is illustrated by photos and blueprint reproductions of the working drawings of the boilers.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine run bases, f.o.b. mines):

Coal	Market Quoting	May. 7, 1923	May 14, 1923
Pool 1,	New York	$3.50–4.00	$3.50–4.00
Smokeless,	Columbus	3.75–4.25	3.85–4.35
Clearfield,	Boston	2.00–3.00	2.25–3.25
Somerset,	Boston	2.25–3.25	2.75–3.50
Kanawha,	Columbus	2.00–2.50	2.00–2.40
Hocking,	Columbus	1.85–2.10	1.85–2.10
Pittsburgh No. 8	Cleveland	2.10–2.25	2.10–2.25
Franklin, Ill.,	Chicago	3.00–3.25	3.00–3.25
Central, Ill.,	Chicago	2.00–2.25	2.00–2.25
Ind. 4th Vein,	Chicago	2.75–3.00	2.75–3.00
West Ky.,	Louisville	1.85–2.00	1.85–2.00
S. E. Ky.,	Louisville	2.15–2.75	2.25–2.75
Big Seam,	Birmingham	1.85–2.25	1.85–2.25

FUEL OIL

(f.o.b. city unless otherwise specified)

New York—May 17, Port Arthur light oil, 22@25 deg. Baumé, 5⅝c. per gal.; 30@35 deg., 5⅞c. per gal., f.o.b. Bayonne, N. J.

Chicago—May 5, 24@26 deg. Baumé, $2.12 per bbl.; 32@36 deg., $2.33 per bbl. tank cars.

Philadelphia—May 14, 26@28 deg. Baumé. Oklahoma, $1.10@$1.15 per bbl.; 30@34 deg., Oklahoma (group 3), 3¼@3¾c. per gal.; 16@20 deg. Seaboard, $1.75@$1.90 per bbl.

St. Louis—May 8, tank-car lots, f.o.b. St. Louis; 30@32 deg. $2.05 per bbl., 26@28 deg., $1.90 per bbl.; 28@30 deg., $2.95 per bbl.; 32@36 deg., gas oil, $2.20 per bbl.; 36@40 deg., distillate $2.35 per bbl.

Pittsburgh—May 10, f.o.b. local refinery, 30@34 deg., fuel oil, 5⅝c. per gal.; 36@40 deg., fuel oil, 5¼c. per gal.; 34 deg., neutral, 9¼c. per gal.

Dallas—May 12, f.o.b. local refinery, 26@30 deg., $1.57 per bbl.

New Plant Construction

PROPOSED WORK

Ala., Heflin—W. M. Dodson, Wedowee, plans to build an electric light and power plant, here. Estimated cost $40,000.

Ala., Russellville—The Bd. of Comrs., A. N. Falls, Pres., plans the construction of a municipal electric light and power plant. Estimated cost $45,000. Owner is in the market for machinery, boilers and equipment.

Ark., Hot Springs—The Arlington Hotel Co., Central Ave., will soon receive bids for the construction of a 6 and 10 story, 200 x 200 ft. hotel, to replace the one which was recently destroyed by fire. Estimated cost $2,500,000. Mann & Stern, A. O. U. W. Bldg., Little Rock, Archts.

Calif., Placienta—The Placienta Orange Growers Assn. is in the market for machinery and equipment for two ice manufacturing plants.

Conn., Meriden—The Connecticut School for Boys, E. S. Boyd, Supt., plans to build a power house. Estimated cost $50,000. Engineer or architect not selected.

Conn., Shelton—The state legislature has appropriated $36,000 for electric elevator equipment to be installed in the State Tuberculosis Sanitarium, here. E. J. Lynch, Supt.

D. C., Wash.—The Chief Signal Officer, United States Army, Munition Bldg., will receive bids until May 25 for 120 dynamotors.

Ga., Dawson—The Dawson Cotton Oil Co. is in the market for a 50-hp. oil engine.

Ind., Hammond—The Bd. Public Works, A. J. Swanson, Chmn., will receive bids until June 1, for furnishing and installing at the Hammond pumping station, surface condenser, intermediate receiver, air pump, condensate pump, pipe, specials, etc., for converting a 15,000,000 gal. snow pumping engine from jet condensing to surface condensing, also, for dismantling, rebuilding, repairing, removing and re-erecting of a 6,000,000 gal. Worthington horizontal, direct acting triple expansion pumping engine and a 15,000,000 gal. snow horizontal, cross compound crank and flywheel pumping engine from the old pumping station to a new one, constructed adjacent thereto. J. Ericson, 30 North La Salle St., Chicago, Ill., Consult. Engr.

Ind., Indianapolis — The Mchy. Clearing House, 424 Bd. of Trade, is in the market for water tube boilers for 1,000 hp.

Kan., Kansas City—The City Electric Light Co., G. T. Darby, Purch. Agt., plans miscellaneous improvements to power plant and the installation of an additional electric generator plant.

Kan., Topeka—A. H. Bennett, Woodlawn Ave., is in the market for a 25 hp. oil engine and a 25 hp. motor for woodworking plant and sawmill.

Ky., Lancaster—The Kentucky Utilities Co., M. E. Taylor Bldg., Louisville, plans additions and improvements to its plant, here, including doubling capacity of power plant and installing an electrically operated ice plant, capacity 20 ton per day. Estimated cost $50,000. Private plans.

Ky., Louisville—The Business Director of the Bd. Educ., 8th and Chestnut Sts., will receive bids until June 1 for alterations to plumbing, heating and ventilating system in Dupont Manual Training High School. Estimated cost $25,000. Lewis & Warren, 1001 Realty Bldg., Louisville, Engrs.

Ky., Louisville—Joseph & Joseph, Archts., Francis Bldg., are receiving bids for the construction of a 7 story, 200 x 260 ft. temple, including an auditorium of 4,600 seating capacity and 150 hotel rooms, on Broadway, for Kosairs. Estimated cost $1,750,000.

Ky., Louisville—The Louisville Gas & Electric Co., 317 West Chestnut St., is having plans prepared by H. M. Byllesby & Co., 208 South La Salle St., Chicago, Ill., Engr., for the construction of an addition to steam power plant on River Road. Estimated cost $150,000.

Ky., Louisville—The United States Engineer's Office, P. O. Box 72, is in the market for one 5 in. vertical shaft centrifugal pump with shaft and motor base for dry dock and Portland Canal.

La., Lecompte—The City Clerk will receive bids until June 12 for the construction and equipment for power plant, including one 50 hp. and one 100 hp. crude oil engine; one motor driven air compressor 8 x 9 with hp. motor; 125,000 gal. concrete reservoir. Swanson-McGraw, Inc., United Fruit Bldg., New Orleans, Consult. Engrs.

Minn., St. Cloud—The Bureau Yards & Docks, Navy Dept., Wash., D. C., soon receives bids for the following work at the U. S. Veterans' Hospital, here, Part 1, new building, tunnels, etc., Part 2, plumbing, Part 3, heating and steam distribution systems, etc., Part 4, lighting and power systems, telephone conduits, electric distributing systems, incl. transformers, panel boards, etc., Part 5, boiler house, equipment and piping, incl. tubular boilers, feed water heater, vacuum, service and fire pumps, etc., Part 6, cold storage refrigerator and equipment complete, etc. L. E. Gregory, ch. of Bureau. Spec. 4848.

Mo., Fulton — The city voted $50,000 bonds for completing improvements to water and light plant. Work will be done by day labor, under the supervision of W. J. McCarroll, Supt.

Mo., St. Louis—The Jewish Hospital Assn., 5414 Delmar Blvd., rejected bids and will have revised plans prepared for the construction of a 6 story hospital on Kingshighway. Estimated cost $1,000,000. Graham, Anderson & Probst, 80 East Jackson St., Chicago, Archts. Noted Jan. 16.

Mo., St. Louis—M. Loew, 1540 Broadway, New York, is having revised plans prepared and will soon receive bids for the construction of a 3 story, 125 x 150 ft. theater building on Washington Ave., here. Estimated cost $1,000,000. T. W. Lamb, 644 8th Ave., New York, Archt. Equipment detail not reported.

Neb., Platte Center — The Henningson Engr. Co., Natl. Bldg., Omaha, will receive bids until May 24 for the construction of well, pumps, 50,000 gal. steel tank on 100 ft. steel tower and 6 blocks of 4 and 6 in. c.i. water mains for the city, here. Estimated cost $17,000.

N. J., Hackensack—The Hackensack Improvement Comn., W. Schaaf, Clk., will receive bids June 4 for the construction of vitrified and cast iron pipe sewers and force mains; three electrically operated pumping stations with pumping equipment, manholes, etc. L. Lozier, Room 3, Bank Bldg., Main and Mercer Sts., Hackensack, Engr.

N. Y., Buffalo—The G. Laub Sons Co., 1051 Clinton St., plans to build a power house. Estimated cost $20,000.

N. Y., Charlotte — The Charlotte Cold Storage Co., Inc., is in the market for cold storage and ice manufacturing machinery and equipment for $250,000 plant.

N. Y., Elba—G. Matthew is in the market for a medium size gasoline engine and auxiliary equipment.

N. Y., New York—The Comr. of Plant & Structures, Municipal Bldg., will receive bids until May 23 for furnishing and installing automatic substation equipment for City Island trackless trolley line, Borough of the Bronx.

N. Y., New York—The Dept. of Public Welfare, Municipal Bldg., will receive bids until May 23 for alteration and construction of an addition to rerfigerating plant at Sea View Hospital, Staten Island.

N. Y., Niagara Falls—The Niagara Falls Hotel Corp. will soon award the contract for the construction of an 11 story hotel on 1st and Jefferson Sts. Estimated cost $1,000,000. Kirkpatrick & Gannon, Gluck Bldg., Archt. Equipment detail not reported. Noted Jan. 16.

N. Y., Phila. — The Antwerp Light & Power Co., Antwerp, J. Baumert, Pres., plans the development of 1,000 hp. under 60 ft. head on the Indian River, here. The work will consist of dam, powerhouse, tailrace and installation of generating equipment. Cost will exceed $150,000.

N. C., Cullowhee—The Bd. of Dirs. of the Cullowhee Normal & Industrial School, R. L. Madison, Supt., will soon award the contract for the construction of gymnasium, laundry, power house, etc. H. A. Underwood, Jt. Bl. Com., Raleigh, Engr.

N. C., High Point—The Lucas Lumber Co., plans the construction of a machine shop, power house and mill. Estimated cost $250,000. Engineer not selected.

N. C., Walnut Cove—The town plans the construction of a municipal electric light and power plant. Estimated cost $100,000. Engineer not selected.

N. C., Washington—The J. N. Swindell Co., plans the construction of a packing plant and power house. Estimated cost $100,000 to $125,000. Engineer or architect not selected.

Ohio, Akron—The Northern Ohio Traction & Light Co., Terminal Bldg., plans to spend $1,250,000 during the coming summer on its lines and stations, about $1,000,000 to be used for extensions to power lines, the balance for construction of substations for reducing voltage of power.

Ohio, Cleveland—The city, c/o Commissioner of Purchases & Supplies, City Hall, will receive bids until May 25 for two 1,400 hp. boilers and superheaters.

Ohio, Columbus—The Dept. of Public Service, W. H. Duffy, Dir. City Hall, is in the market for a 7,500 kw., 80% power factor, 2 phase, 50 cycle, 2,300 volt condensing turbo generator set; foundation for turbine and generator; switchboard equipment, cables and ducts; air ducts; surface condenser with dual drive circulating and condensing pumps and air ejectors; expansion joint between turbine and condenser; foundation for condenser; steam and exhaust lines; suetion and discharge lines for circulation pumps; back outlet gate valve between turbine and condenser; steam separator; water intake at river; traveling water screens; air washer. Estimated cost $235,000.

Ohio, Columbus—The Maple Grove Coal Co., 2261 Cleveland Ave., E. E. Riley, Purch. Agt., is in the market for mining machinery and electric power plant unit for development of tract of coal land in Harrison County.

Ohio, Youngstown—McCrory Stores Corp. is having plans prepared for the construction of a 6 story store and office building on West Federal St. Estimated cost $1,000,000. C. F. Owsley, Mahoning Bank Bldg., Archt. Equipment detail not reported.

Okla., Tulsa—L. R. Shumway, Archt., 603 Wright Bldg., will receive bids until June 1, for the construction of a 10 story, 100 x 140 ft. addition to hotel on 3rd and Cincinnati Sts. for H. R. Ketchum. Estimated cost $500,000. Equipment detail not reported.

Ore., Portland — The Medical Society, Medical Bldg., will receive bids until Aug. 1, for the construction of a 6 story, 100 x 200 ft. office building on 10th and Taylor Sts. Estimated cost $650,000. Houghtaling & Dougan, Elks Bldg., Archts. Heating and plumbing system will be installed under separate contract.

Pa., Gettysburg—The Gettysburg Ice & Cold Storage Co. is in the market for ice manufacturing machinery.

Pa., Harrisburg—The Bd. of Comrs. of Public Grounds & Bldgs., Office of Superintendent, Capitol Bldg., will receive bids until May 24 for furnishing and installing two low pressure water tube boilers, electrically driven vacuum pump and connecting to feed and return lines of present heating system and to the present smoke stack.

Pa., Phila.—The United States Fidelity Guarantee Co., 315 Walnut St., will soon award the contract for the construction of a 4 story, 53 x 94 ft. office building at 129 South 5th St. Estimated cost $500,000. Porter, Thomas & Rice, Union Trust Bldg., Baltimore, Md., Archts. Equipment detail not reported.

Pa., Phila.—F. E. White, Archt., Pennsylvania Bldg., is receiving bids for the construction of a 26 story, 84 x 119 ft. hotel, including vapor heating system, on 15th and Ranstead Sts. for the Kugler Hotel Co. Estimated cost $5,000,000. Noted Apr. 17.

Pa., Pottstown — The Pottstown Cold Storage Co. is in the market for air compressors, air tanks, transmission and other cold storage equipment.

Pa., Scranton—The Scranton Electric Co., Bd. of Trade Bldg., D. C. Campbell, Vice Pres., is in the market for power plant equipment, including boilers, generators, turbines, etc., to cost about $1,000,000.

S. D., Watertown—The Municipal Utilities Comn., A. M. Myhre, Secy., will receive bids until May 29 for the construction of a filtration plant, including complete filter with appurtenances, pumping equipment, including two low head raw water pumps and one wash water pump. Estimated cost $55,000. W. T. Cochrane, City Engr.

Tenn., Elizabethton—The Marsh & York Lumber Co. is in the market for one 50 hp. oil engine.

Tenn., Knoxville—The Duncan Mchy Co., Dempster Bldg., is in the market for a 150 hp. boiler and a 100 hp. engine.

Tenn., Milan—The city, H. P. Webb, Mayor, is in the market for boilers, meters, etc., for light and water plant.

Tex., Beaumont—Jefferson County, A. C. Love, County Engr., will soon award the contract for the construction of a steel bascule span bridge with timber pile and concrete pile trestle approaches, total length 3,015 ft. Machinery, including two 80 hp. operating motors, one 3 hp. lock motor controllers, switchboard, wiring, solenoid brakes and one gasoline auxiliary engine, etc., will be required.

Tex., Christine—V. H. Williams and Associates representing the San Antonio & Rio Grande Valley Traction Co., Dallas, are having surveys made for the construction of an electric railway from San Antonio to the Lower Rio Grande Valley, also a large power plant will be built on the new line where it crosses the San Miguel River near McMullen County Steel Bridge. The company has large lignite coal fields there, and the power plant will supply power for these fields and the proposed electric railway line. Estimated cost $2,000,000. C. Shonat, Muskegon, Mich., Engr.

Tex., Dallas—The Dallas Power & Light Co., Interurban Bldg., will build a power house along tracks of the Missouri-Kansas-Texas R. R. Estimated cost $398,167.

Tex., Dallas—The Dallas Textile Mills Co., Interurban Bldg., J. P. Burrus, Pres., has had plans prepared and will receive bids in the summer for the construction of a 2 story cotton mill to contain 150,000 sq.ft., power plant, etc., in the Love Field Ind. Dist. Estimated cost $1,000,000. L. W. Robert, Jr., Tufts Bldg., Atlanta, Ga., Engr. Owner is in the market for machinery for mill and equipment for power plant, etc.

Tex., Spearman—The city voted $43,000 bonds for the construction of a complete waterworks system, also $12,000 bonds for electric light plant. Engineer not announced.

Va., Richmond—The city will soon receive bids for the construction of a new pump house to be built adjacent to present station, south of Board Park, capacity 40,000,000 gal. per day.

Wis., Chippewa Falls—The city, L. J. Felix, City Clk., plans to build a dam and power house at Brunet dam site, to furnish city power and light. Engineer or architect not selected.

Wis., Green Bay—The Northwestern Cold Storage Co., 409 North Washington St., C. A. Straubel, Purch. Agt., is in the market for refrigeration machinery, several ton capacity.

Wis., Little Chute—The village, M. Van Hoof, Clk., is having plans prepared for the construction of a waterworks system, including deep well, pumping station, mains and meters. Estimated cost $120,000. A. E. McMahon, Menasha, Engr. Noted Apr. 24.

Wis., Madison—The St. John's Lutheran Congregation, c/o O. J. Wilke, is having plans prepared for the construction of a steam heating plant and boilers for church building. R. A. Phillips, Beaver Bldg., Madison, Engr.

Wis., Madison—A. J. Sweet, 639 West Wilson St., is having plans prepared for the construction of a 1 story, 60 x 90 ft. cold storage plant and warehouse. Estimated cost $40,000. R. A. Phillips, Beaver Bldg., Madison, Archt. The architect will purchase refrigerating machinery and a 20 ton ice machine.

Wis., Madison — The Wisconsin Hotel Realty Co., 86 Michigan St., Milwaukee, will soon receive bids for the construction of a 12 story, 132 x 144 ft. hotel on West Washington and Fairchild Sts., here. Estimated cost $1,500,000. M. Tullgren & Sons Co., 425 East Water St., Milwaukee, Archts. Equipment detail not reported. Noted May 8.

Wis., Manitowoc—The city, A. K. Zander, Clk., is having plans prepared for the construction of a 60 x 90 ft. addition to municipal water and light plant. Estimated cost $40,000. F. Alter, City Hall, Engr.

Wis., Milwaukee—The Western Leather Co., 878 Marshall St., is receiving bids for the construction of a 42 x 140 ft. boiler house. Estimated cost $40,000. E. R. Liebert, 432 Bway., Archt. Noted Mar. 6.

Wis., Mosinee—The city, E. A. Bachman, Clk., plans to build a pumping station, pumps and equipment for water supply system. Engineer not selected.

Wis., Shorewood (Milwaukee P. O.)—The village, T. B. Olsen, Clk., has had plans prepared and will soon receive bids for the construction of a street lighting system, including 90,000 ft. of underground trenching, 100,000 ft. of wire, 400 transformers, etc. Estimated cost $85,000. A. J. Sweet, 531 Grand Ave., Milwaukee, Engr. Noted Feb. 20.

Alta., MacLeod—The municipality, E. H. Oliver, Supt., plans an additional unit for the power plant, approximately 250 kw. capacity. Natural or producer gas.

B. C., Vernon—The City Council is having plans prepared by the City Engineer, City Hall, and will receive bids in about a month for the construction of a pumping station and artesian well in the city park. Estimated cost $30,000.

Ont., Campbellford—The Hydro Electric Power Comn., W. W. Pope, Secy., 190 University Ave., Toronto, will receive bids until May 25, for the construction of power house, foundations and tailrace excavation for the hydro-electric development at dam No. 8 on Trent River. Estimated total cost $1,066,408. F. A. Gaby, c/o Owner, Engr. Noted April 10.

Ont., Toronto—The Milnes Coal Co., Ltd., 88 King St. E., plans to build a coal handling plant with storage bins, unloading pocket and elevating apparatus, electric power at 1520 St. Clair Ave. Estimated cost $30,000.

Ont., Toronto—The Wasapika Consolidated, Ltd., c/o Simons, Agnew & Co., McKinnon Bldg., is in the market for machinery and equipment for power house at Wasapika.

Ont., Welland—The Canadian Atlas Crucible Steel Co. is in the market for a 500 hp. electric motor, 750 r.p.m., 4,400 volt, 3 phase, 25 cycle, wound rotor or slip ring, 40 deg. rating.

Que., Montreal — The Jamaica Hydro-Electric Co., Ltd., c/o H. N. Chauvin, 232 St. James St., is in the market for machinery and equipment.

CONTRACTS AWARDED

Calif., Placerville—The Western States Gas & Electric Co., Channell and Sutter Sts., Stockton, awarded the contract for building a 72 in. butterfly valve to operate under a head of 65 ft. installed at the head of the penstock at the Eldorado plant near here, to the Pelton Water Wheel Co., 19th and Harrison Sts., San Francisco.

Calif., Stockton—The Natl. Ice & Cold Storage Co., Taylor and Center Sts., awarded the contract for the construction of an ice and cold storage plant, to replace the one which was destroyed by fire, to the Davis-Heller-Pearce Co., Delta Bldg., Stockton. Estimated cost $50,000.

Ky., Louisville—The United States Engineer Office, P. O. Box 72, awarded the contract for one 10 hp. fuel oil engine, horizontal, 2 cycle, semi-diesel to the Muncie Oil Engine Co., Muncie, Ind., $730. Noted Apr. 17.

Me., South Portland—The Maine Central Ry. Co., Portland, awarded the contract for the construction of locomotive and car repair shops, engine house, power plant, etc., to the J. W. Gulliver Co., 120 Exchange St., Portland, F. A. Rumery Co., 21 Portland St., Portland, J. J. Prindiville Co., South Framingham, Mass. Estimated cost $1,250,000.

Mich., Ann Arbor—The University of Michigan awarded the contract for the construction of a law school on South Michigan Ave. to Starret Bros., Inc., 101 Park Ave., New York. Estimated cost $2,000,000. Equipment detail not reported. Noted Apr. 10.

Mich., Iron Mountain—The Ford Motor Co., Highland Park, awarded the contract for design and construction of a 10,000 hp. hydro-electric plant on Menominee River to Stone & Webster, 147 Milk St., Boston, Mass. A 375 ft. dam and the power station sub-structure will be designed by Mead & Seastone, State Journal Blk., Madison, Wis. Three 3,200 hp. vertical type, water wheels will be installed to operator under 30 ft. head and direct connected to 13,200 volt generators.

Mich., Zilwaukee (Saginaw P. O.)—The Consumers Power Co., Jackson, awarded the contract for the construction of a hydro-electric power plant, capacity 105,000 kw., 60 cycle, a.c., here, to O. W. Jenkins, 223 South Washington St., Saginaw; machinery erection to B. Douglas Co., Ann Arbor. Noted Apr. 10.

Minn., St. Paul—The Ford Motor Co., Highland Park, Mich., awarded the contract for the construction of a combined hydro-electric and steam power plant, 18,000 hp., at the high dam to Stone & Webster, 147 Milk St., Boston, Mass. Noted Jan. 30.

New York—The Power Corp, of New York, Northern New York Trust Co. Bldg., Watertown, awarded the general contract for additional hydro-electric development of the Northern New York Utilities plant, at Effley Falls, consisting of the raising of the present dam 5 ft., changes in the present canal and power house substructure, to Burns Bros. & Haley, Inc., Watertown; a 2,100 hp. vertical turbine to S. Morgan Smith Co., York, Pa., and a 2,000 kva. generator and other electrical apparatus to the General Electric Co., Schenectady. Noted April 10.

N. Y., Herring—The Power Corp. of New York, Northern New York Trust Co. Bldg., Watertown, awarded the general contract for hydro-electric power development of the St. Regis Paper Co., consisting of the construction of masonry dam, substructure of the power house and excavation of the tail race, to the Foundation Co., 120 Liberty St., New York; three 2,170 hp. vertical turbines to the Allis Chalmers Mfg. Co., Milwaukee, Wis. The generators and electrical equipment have not been purchased. Noted April 10.

N. Y., Watertown—The city council, J. W. Ackerman, Mgr., awarded the contract for generators and switchboard for municipal power development at Delano Island, to the Westinghouse Electric & Mfg. Co., 165 Bway., New York, $84,854. Noted April 3.

N. C., Raleigh—The State Bldg. Com. awarded the contract for the construction of a gymnasium, cold storage plant, etc., to Jewell, Riddle & Co., Sanford. Estimated cost $150 000. Bids for heating system, etc., will be received later. Noted Apr. 24.

S. D., Conde—The city awarded the contract for the construction of a waterworks system, including 2 mi. of 4 to 8 in. c. i. pipe, 60,000 gal. elevated tank, 75,000 gal. reservoir and one 6 x 8 triplex pump to the Phelps-Drake Co., 719 Metropolitan Life Bldg., Minneapolis, Minn. Estimated cost $33,000. Noted Apr. 24.

Wash., Oroville—The Washington Water Power Co., 825 Trent St., Spokane, awarded the contract for furnishing a 2,500 hp. double runner cylindrical-case reaction turbine, to operate under a 20 ft. head, to be installed at the Similkameen River plant here, to the Pelton Water Wheel Co., 19th and Harrison Sts., San Francisco, Cal.

Wis., Milwaukee—The Misericordia Hospital, 22nd and Chestnut Sts., awarded the contract for the construction of a 2 story, 50 x 100 ft. power house and laundry to E. Steigerwald Sons, 2303 Galena St., Milwaukee. Estimated cost $40,000. Noted Mar. 6.

Wis., Milwaukee—The Pittsburgh Plate Glass Co., 213 Lake St., awarded the contract for three 350 hp. boilers to the Heine Boiler Co., 5319 Marcus St., St. Louis, Mo.; type E stokers to the Combustion Eng. Corp., 43 Broadway, New York; fans and fan engines to the Claridge Fan Co., North and Porter Sts., Kalamazoo, Mich. Noted Feb. 27.

Ont., Lansing—The Twp. of North York, H. D. Goode, Clk., awarded the contract for the construction of concrete dam, pumphouse and filtration plant, to A. R. Campbell & Co., Toronto, $39,230; pumps, motors, etc., to Bawden Machine Co., 163 Sterling Rd., Toronto, $12,117; filter equipment to Canadian International Filter Co., Confederation Life Bldg., Toronto, $12,050; elevated steel tank to Horton Steel Co., Bridgeburg; c.i. pipe to Natl. Iron Pipe Co., Cherry St., Toronto, $19,000; laying mains to Rusceca Bros. & Co., 256 Ontario St., Toronto, $4,426; tank foundations to Roco & Co., c/o James, Proctor & Redfern, Ltd., Engrs., 36 Toronto St., Toronto, $2,065. The contracts for valves and hydrants, estimated cost $35,000, have not been awarded. Noted Apr. 10.

Ont., Sutton—The village, F. G. Tremayne, Clk., voted $30,000 bonds for the construction of 10 mile transmission line and a sub-station. Work will be done by day labor, under the supervision of the Hydro Electric Power Comn. of Ontario, University Ave., Toronto. Wire, poles, cross arms, insulators, pins, transformers, switches and other sub-station equipment will be required. Noted Mar. 20.

Ont., Timmins—The Hollinger Gold Mines, awarded the contract for pumping equipment for fire protection for mine and city water supply, consisting of two 10 in. two stage pumps, driven by 350 hp. electric motors; two 8 in. stage pumps, driven by 200 hp. electric motors; two 8 in. single stage pumps, driven by 75 hp. motors. All pumps centrifugal, electric motors, 25 cycle, 3 phase, to Turbine Equipment Co., Ltd., 73 King St., West Toronto, and the English Electric Co. of Canada, McKinnon Bldg., Toronto.

Ont., Toronto — The Toronto Electric Comrs., 225 Yonge St., awarded contracts for the construction of a 2 story electric substation on Bay St., as follows: excavation to Lioni & Co., 1450 Dufferin St., Toronto; structural steel to the Hamilton Bridge Co., Genl. Accident Bldg., Toronto; plumbing to the Mechanical Trades Co., Ltd., 54 University Ave., Toronto. The owner is in the market for electrical transformers, oil switches and traveling crane.